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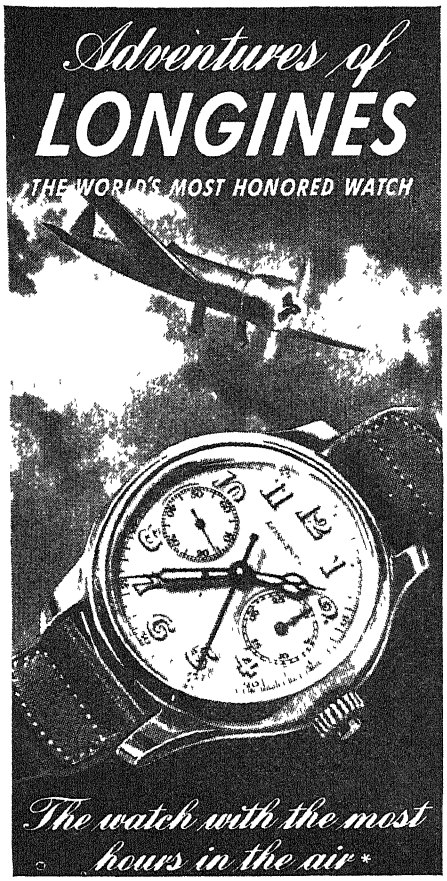

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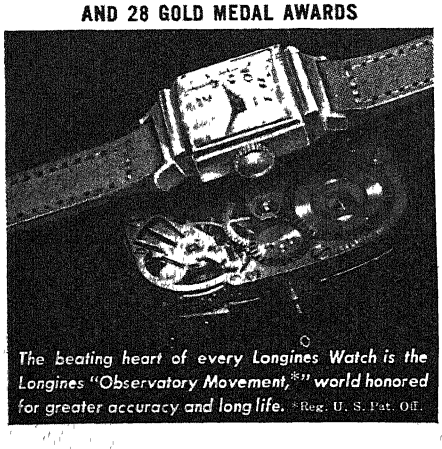

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Scientific American

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COVER: One of the multitudinous uses of compressed air (see also page 24) is in the metallizing process, coming into wide use, among others, as a means of corrosion prevention. Our front cover illustration, by Robert Yarnall Richie, shows one application of this process—spraying a coating of pure aluminum onto the cylinders of a Cyclone aircraft engine in a plant of the Wright Aeronautical Corporation. This aluminum coating is highly resistant to salt water corrosion, protects the underlying cylinder.

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Previews of the Industrial Horizon

By A. P. Peck

PAPER—NOW AND LATER

PAGE margins of this issue of Scientific American will be noted by all, commented upon, probably criticized by many. The underlying reason, of course, is obvious: Paper conservation. Trimming a quarter inch or so from the blank margins saves a tremendous amount of paper over the course of a year, a saving that must be made if publications are to continue operations under the stress of war-caused shortages.

All of which brings us to the condition of the paper industry now and in the future. Despite the wide-spread knowledge that forests cannot be indiscriminately logged indefinitely, many pulp-wood producers have been blithely continuing with little or no thought for the future. Result: There is little forestry reserve in the United States today and the vast timberlands of Canada are facing exhaustion.

Add to this the other uses for wood that have been developed in recent years—in plastics, explosives, construction work, for examples—and it is obvious that unless something is done, and done vigorously and thoroughly, the paper industry is going to face an even greater crisis after the war than it is facing today. Scientific forestry management in all its phases must be applied to all forest reserves instead of to a scattered few as in the past. Only through such means can future pulp supplies be assured, not alone for the production of paper but also for the multitude of uses which chemistry is developing and has developed in the recent past.

AUTOMOBILES TOMORROW

A GLIMPSE of possibilities in the automobile field of the future, afforded by speakers at a recent convention of the Society of Automotive Engineers, shows a desirable trend toward increased economy of operation. Not only is this desirable from the standpoint of running costs but, more important, from the angle of reduced drains on fuel reserves. Better fuels we now have, born of military demands. Such fuels point to possible 30-mile-per-gallon economy with cars of present weights; even better with lighter-weight vehicles. Also, there is going to be a continuation of the race between fuel chemists and engine designers, with the public as the ultimate beneficiary.

CARGO BY AIR

VIEWED from this vantage point, it appears that, while air-cargo mileage in the future will continue to mount with satisfactory rapidity, there is little or no danger that such operations will have serious effects on surface transportation. Rather, indeed, the cargo plane should shortly prove to be a valuable supplement to established means of delivering goods from one point to another. High-speed transportation will develop new business for all, resulting in increased activity not only in the air but on the ground and on the water as well.

Some of the present and future aspects of air cargo work are presented in the article on page 13.

ON THE RADIO WAVES

A REVOLUTION—minor, perhaps, but a revolution nonetheless—is in the making in the radio field. Well known is the fact that military communications methods will later redound to the benefit of all communications. Add to this the fact that the frequency-modulation method of broadcast transmission and reception is on the way up and it may safely be stated that radio entertainment in the future will reap the advantages of technological advance.

Today there are 900 amplitude-modulation transmitters in the United States, but only 53 of the frequency-modulation type. Every day hundreds of radio receivers are going out of service through lack of replacement parts. These represent a market that by the end of the war, will be tremendous. And here is where frequency-modulation will get its chance It is estimated that by five years after peace arrives there will be only 750 AM stations on the air, but that FM will have climbed to at least 500. And in the interim there will be the revolution in receiver design and sales, based on the advantages and disadvantages of the two systems.

MANAGEMENT CAN LEARN

INDUSTRIAL executives who fail to develop and encourage the ingenuity of their workers are missing a good bet in more ways than one. The War Production Board's drive for stimulating suggestions from employes is bearing fruit in many industries, bringing forth time, material, and labor-saving methods, and building employe morale at the same time.

The man who does the actual work on a specific job often sees things about it which his boss would overlook. When the workman puts forth an acceptable suggestion, management and the war effort benefit; the worker himself likewise should gain through material award but, what is even more important, he receives the psychological lift of personal accomplishment. The management that does not build on the basis of employe co-operation is short-sighted indeed.

ELECTRONICS AND WALL STREET

BEARING out predictions regarding the future of electronics in industry are the facts that a series of lectures on the subject has been delivered in the Governing Room of the New York Stock Exchange and that various financial analyses of probabilities have been made and published by Wall Street houses. When the Street takes this much interest in science, it is sure that the interest is not engendered by any academic aspirations on the part of market men.

TELEVISION RECEIVERS

A BROAD survey of public interest in television, recently completed by RCA, indicates that, when radio-picture receivers are made available, a large portion of the public would be willing to spend as much as $200 for one. On this basis RCA estimates that, granting the construction of adequate transmission facilities, there will be a market five years after the resumption of commercial television, for receivers in this price class at a rate of approximately 2,500,000 units per year.

LET THERE BE LIGHT

RECENT developments in luminous paints of various types, now finding wide military applications, hold promise of extensive civilian use when they become available after the war. These paints, now far superior to any heretofore made, will become markers for stairways, light switches, and so on; even, some say, for modified room lighting.

And then there are methods of illuminating instrument panels in aircraft through the use of "black light." By this means there is no direct light in the cock-pit, hence no glare to render seeing difficult. Here is something for transplantation into the automobile of tomorrow.

50 Years Ago in . . .

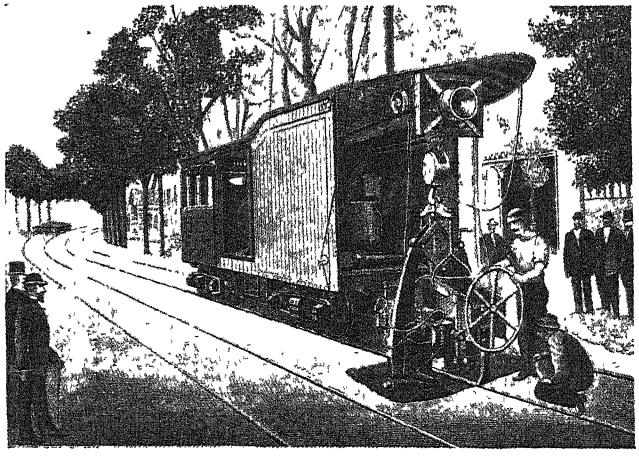
SCIENTIFIC AMERICAN

(Condensed from Issues of January, 1894)

CHEMISTRY — "The young giant, chemistry, has a future before it which involves that of the race of man more intimately and more completely than all the other sciences combined. . . . The great amount of more or less random research yet prevailing proves that chemistry is as yet but an infant, destined to a gigantic growth—a growth in fact illimitable"

DEEPEST MINE — "The United States has now, we believe, the deepest metal mine in the world . . . The No. 3 shaft of the Tamarack Copper Mining Company, in Michigan, which on December 1st was 3,640 ft. deep, and is now more than 3,700 ft., the average rate of sinking being about 75 ft. a month."

WELDED RAILS — "After conclusive experiments on expansion effects in street-car rails made by the Johnson Company, it was decided to apply welding to a tramway line that had been laid for two years by the West End Street Railway between Boston and Cambridge The materiel necessary for the operation was ordered from the Thomson Electric



Welding Company. The first experimental welding was done with this materiel upon a foot rail of the Johnson type. . . . The welding took an electric power of 150 kilowatts, furnished by the continuous current actuating the tramway from Lynn to Boston. It was this materiel that was utilized . . . at Cambridge, upon a length of nearly two miles. The illustration gives a general view of the special car devised for the welding of rails in situ. The box of the car contains the materiel necessary for the production of the alternating current and the regulation of it. The front is reserved for the welding apparatus."

IRON STRENGTH — "An official statement of tests made at the Massachusetts arsenal to ascertain the effect of temperature on the strength of iron has been published. . . . The results present the interesting fact that the specimens in question were all stronger in the neighborhood of zero than they were at ordinary temperatures—all of them, in fact, showing a minimum of strength at 210 deg. or thereabout, and a maximum of strength at about 550 deg."

TUNNEL ELEVATORS — "Between Finnieston and Govan, two tunnels have been laid under the Clyde, side by side, one for vehicular traffic going north and the other for that going south. Above these two, and over the point of junction, there is a third tunnel for foot passengers. At either end of these tunnels, and close to the riverside, vertical shafts have been constructed, each 80 feet in diameter. In each of these shafts there are to be six powerful lifts, designed to lower and lift the largest vans, lorries, etc, with their horses, just as they are. On being lowered to the bottom, they will go, as on a road, through the tunnels, and be raised at the opposite end"

PEANUTS — "Dr P. Furbringer treats of the peanut as an article of food rich in albumen, of which it contains forty-seven per cent, together with nineteen per cent of fat and non-nitrogenous extractive matters He recommends the use of roasted peanuts in the form of soup or mush"

ENGINES — "It was but a few years ago that the gas engine was but little better than a toy, noisy and expensive in its operation and with but little promise of ever becoming a rival of the steam engine Now, however, their action (in the best makes) is smooth and regular and their economy compares favorably with that of the steam engine"

SCULPTURING — "We have recently had an opportunity of examining a new application of electricity that is worthy of being made known It is a question of a sculpturing machine actuated electrically. This machine is evidently not designed to replace the hand of artists, but is valuable for making copies, and is capable, in a short time, of making rough-hewn statues, upon which the talent of the professional sculptor can afterward exercise itself usefully."

STREET CAR — "A tramway company near London is trying a new car on a portion of its route. The car is known as the Luhrig gas car, and is a German invention, propelled, as its name implies, by means of gas. It is self-contained and has a running capacity for about 15 miles. Refilling can take place in about 70 seconds through an ordinary India rubber delivery hose fastened on to a nozzle in the body of the car."

CORROSION-PROOFING — "Mr. W. Thomson recently read a paper before the Manchester Association of Engineers, on 'The Influence of Some Chemical Agents in Producing Injury to Iron and Steel,' in which reference was made to the effects of different paints and varnishes used for the preservation of structural iron and steel from rust. From experiments made by himself, Mr. Thomson has arrived at the conclusion that red lead paint is the best preservative"

ALLOYS — "The alchemists of the Middle Ages were incessantly occupied with the endeavors to transmute metals. Many alloys were known to them which are lost to us, and their recipes contain many useful hints, worthy of the attention of modern scientists."

PRE-MOVIES — "One of the uses of the optical lantern is to perpetuate beautiful forms and scenes, thus cultivating the taste and increasing the knowledge of multitudes who could never have seen the objects themselves"

TANKERS — "Almost all the molasses which comes from Cuba to the United States is brought in the same tanks in steamships that are used to carry petroleum as a return cargo. . . . It might be supposed that the petroleum would have a bad effect on the molasses, but it has been shown that the contrary is the case, and as nearly one-half the importation is made into rum and the balance refined into sugar, a little oil is not of much account."

WATER-PROOFING — "What was at first considered a doubtful experiment, viz., the use of coal tar as a means of rendering masonry impervious to water, especially in positions exposed to direct contact with the latter, has proved a practically valuable resort."

ICE — "The Massachusetts State Board of Health concludes, from investigations of artificial ice, that artificial processes of freezing concentrate the impurities of the water in the inner core or the portion last frozen, that the impurities are least if distilled water is used, that the number of bacteria in artificial ice is insignificant, under the prevailing methods of manufacture, and that the amount of zinc found in ice is insufficient to cause injury from its use."

THE SEARCH THAT NEVER ENDS

IN THE industrial life of America, research has been of constantly increasing importance. And today it is a national resource, for the research of industrial and college laboratories is proving its value in War.

To the Bell System, research is an old idea, for the telephone itself was born in a laboratory. Behind its invention, sixty-nine years ago, were researches in electricity and acoustics and in speech and hearing.

And, ever since, there has been a laboratory where scientists have searched to know more about these subjects; and with their associated engineers have applied the new knowledge, fitting it with all the old, to make the telephone better and better.

Their fields of inquiry have broadened and deepened through these years; they inquire into all the sciences and engineering arts which have any promise of improving the telephone. Much has been learned but still more will be, because their search goes on. That is why the telephone laboratory grew to be Bell Telephone Laboratories, Incorporated, the largest industrial laboratory in the world. And it exists to improve telephone service.

Improvements in industry can be left to chance in the hope that some one, sometime, will think of something useful; that some good invention will turn up.

The other way to make improvements is to organize so that new knowledge shall always be coming from researches in the fundamental sciences and engineering arts on which the business is based. From that steady stream will arise inventions and new methods, new materials and improved products.

This is the way of Bell Laboratories. Its search will never end. And as fast as it can the Laboratories will apply its new knowledge practically to the design of equipment and communication systems.

At present—and this started before Pearl Harbor—its trained scientists and engineers and all their skilled associates are concentrating on products of importance to our armed forces. But when this work is happily over they will be ready to continue their developments for the needs of peace.

BELL TELEPHONE SYSTEM

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In these critical times, the nation needs engineers of executive ability *now, today* —not five, or ten years from now! The shortage of such men is acute—even more acute than that of skilled production workers. And company heads, aware of this situation, are offering high rewards to engineers who have the necessary training in industrial management.

Golden Opportunity for Engineers

In this new era, the engineer with vision and foresight has a golden opportunity. He will realize that out of today's tremendous production battles will emerge technical men who not only will play a major role in winning the war, but who also will be firmly entrenched in key executive positions when peace comes.

However, before the engineer can take over executive responsibilities, he must acquire knowledge of the other divisions of business—of marketing, accounting and finance. He has of necessity a vast amount of technical training and experience. But in order to grasp the opportunities that present themselves today—to assume leadership on the production front—he must *also* have an understanding of practical business principles and methods.

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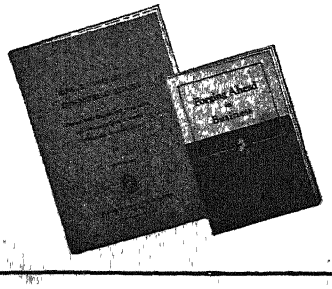

134,000 men on the operating side of business have enrolled for this training. More than 37,500 are technical men—engineers, chemists, metallurgists—many of whom are today heads of our huge war industries.

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"NOT ONLY must the business man have incentives to utilize what equipment he has, but in our type of society there must be a constant expansion in employment facilities if we are to have prosperity" *Dr Emerson P Schmidt*

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" " "

"THE SHORTER distance travel market—the really mass travel market—has hardly been touched by air transport. It represents perhaps the largest chunk of travel business potentially available to our domestic airlines." Charles I. Stanton, Administrator of the Civil Aeronautics Administration

" " "

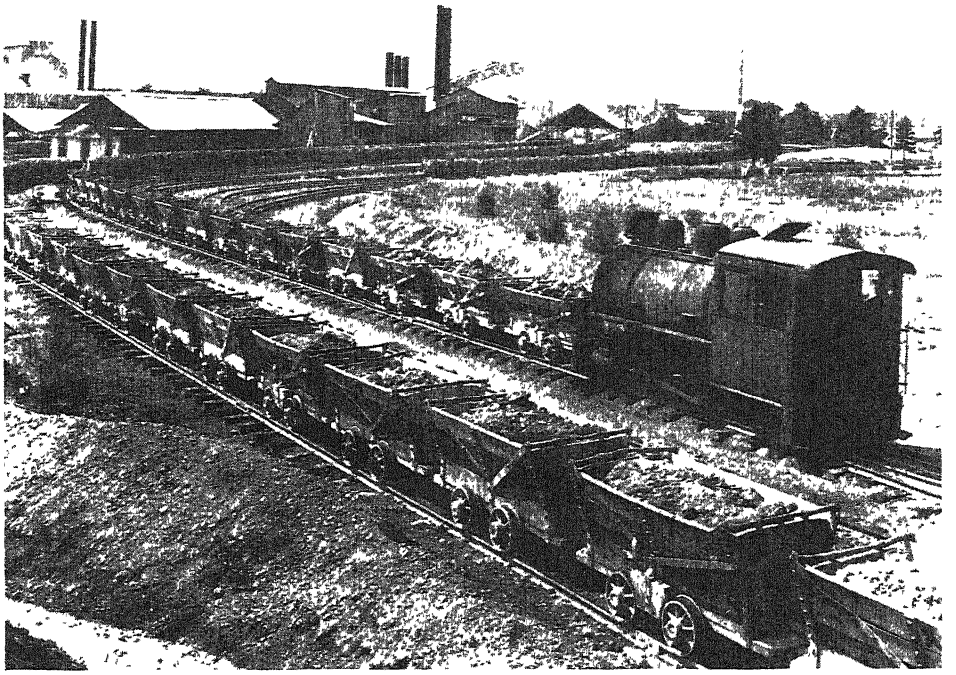
"FOLLOWING the war our agricultural research must be sufficiently broad and inclusive to insure our own security and comforts beyond anything we have yet known, and to provide the much needed co-operation in a world-wide program of research designed to establish a more universal security and, we hope, a more permanent peace." *Dr. W. H. Tisdale, Director, Du Pont Pest Control Research Laboratory*

" " "

"THE ANNUAL need rate (for housing) has been at the high level of approximately 900,000 homes for the 1931-1941 period, while only an average of 350,000 housing units were built per year during the same period. A need backlog in excess of five million housing units has, therefore, accumulated. If spread over a 10-year post-war period, it would place the annual total housing need potential at 1,400,000 homes." Irving W. Clark, Westinghouse Electric and Manufacturing Company.

CHEMISTRY IN INDUSTRY

Conducted by D. H. KILLEFFER



Bauxite goes to one of the mills of the Aluminum Company of America

As Metal Resources Dwindle

The Point of Scraping the Bottom of Some of the Mineral Barrels is Rapidly Approaching. Rich Iron and Aluminum Ores are Nearing Exhaustion, but the Chemical Industry is Doing Things about the Development of Methods of Working Wide-Spread Low-Grade Ores

AMERICANS are faced with a new and strange emergency. Certain of the richest mineral resources of the nation are in alarming danger of exhaustion. Conservationists have from time to time urged care in using this or that raw material lest present-day extravagance impoverish future generations. Yet the enormous rate of depletion of natural deposits of economic minerals to meet the necessities of global war brings impoverishment of some of them so close that the present generation must do something about it for its own protection.

Post-war planners—and who is not one now?—find themselves face to face with a new problem of supplies which already is alarming in its implications. Capacity to produce has soared and so, of course, has the consumption of raw materials. Shortages, developed in war production have been laid to bottlenecks of manpower, of processing plants, of transportation: the state of inventories of minerals could not be considered under pressure of war. However, planning for the future must be based on availability of supplies and it now becomes clear that the point of scraping the bottom of some of the mineral barrels is rapidly approaching. Furthermore, evidence accumulates that the problem of the future can be solved only through a broadening of our mineral base which involves amplification of available metallic ores through development of methods for economical working of those ore bodies now considered too poor.

The solution obviously lies in the field of chemistry and chemical industry, for the processes employed are fundamentally chemical. That ores of low concentration can be utilized is amply attested by past accomplishments of chemical industry in recovering traces of needed elements. Outstanding is the working of sea water for its 0 0064 percent of bromine and its 0.13 percent of magnesium. Both of these are produced now in competition with richer sources While the methods employed on ores will differ radically from these, the basic chemical technology and ingenuity required for developing needed new techniques are amply available to meet the new emergencies now imminent

Present-day magnified aluminum production threatens exhaustion of high-grade bauxite ores within three or four years. Heavy drains on our richest and most cheaply available iron ore deposits in the Mesabi Range in Minnesota are sapping its life. Present estimates place the life of our invaluable petroleum reserves at 12 years. Tin ores in the United States are negligible and lead and zinc have never been abundant. Our richest copper ores are dwindling in the face of our enormous use of this metal for war purposes.

It is obvious that our traditional careless attitude toward mineral resources

cannot continue New direction must be given post-war planning, lest what is now alarming become grave in the extreme Indeed, any valid plan for tomorrow must of necessity be based on the fundamental availability of minerals and not on any naive faith in the complete adequacy of our resources

Frederick W Willard has recently emphasized the essential, but universally neglected, fact that of the 92 known chemical elements only eight combine to form more than 98 percent of the composition of the earth The remaining 84 constitute less than 2 percent of the total Among the eight plentiful elements only three—aluminum, iron, and magnesium—are metals that lend themselves to structural uses by any technology which has so far been achieved Moreover, these eight elements, including the three structural metals, are so plentifully distributed throughout the world that every considerable area possesses them in some semblance of abundance

THINKING out the problem of the future on such a basis yields a plan of far-reaching consequences for the peaceful development of the world, yet one which requires the solution of vital problems of science and technology.

In the light of the basic fact of plentiful distribution of essential elements over the face of the earth, the statements with which this article started may appear to be ridiculous. Yet the growing scarcity of high-grade ores of both aluminum and iron cannot be gainsaid; only the significance of this scarcity changes against the factual background. Search for new deposits of high-grade ores is naturally the first necessity, but far more important is the development of a new technology to win both metals from ores now outside the economically workable range of present methods.

High-grade bauxite is definitely limited in geographical distribution within our own country and elsewhere and also in the fraction which it constitutes of the world's aluminum supply Present technology is based on refining this important metal from such high-grade ore, a hydrated aluminum oxide. This procedure is satisfactory so long as rich ores can be had in sufficient abundance However, bauxite occurs in pockets of limited extent and forms only a tiny fraction of the total potential aluminum in the world. Thus the end of commercially economical deposits of this ore is swiftly approaching. Yet aluminum is definitely the most plentiful metal in the world—at least half again as plentiful as the next one, iron—being found also in clays of which abundant supplies are universally distributed. The aluminum content of clays, which may be as high as 25 percent, is combined as a silicate, however, and is difficult to separate from impurities and to recover

CHEMICAL ELEMENTS OF THE EARTH

Oxygen	46.46%
Silicon	27.61
Aluminum	8.07
Iron	5.06
Calcium	3.64
Sodium	2.75
Potassium	2.58
Magnesium	2.07
84 other elements	1.76
	100.00%

Technology is already grappling with the problem of winning the metal from these sources now largely neglected Ultimate success in utilizing clays is still in the future, largely, be it noted, for economic reasons. Several methods have been devised for this purpose but none can yet compete with bauxite in cost, except as a war measure.

The situation of iron is similar to that of aluminum, with the important difference that abundant low-grade iron ores have a character similar to the best, distinguished only by diminished iron content. With aluminum, bauxite differs sharply from clay in chemical constitution, iron ores, on the other hand, are mixed oxides and hydrates whose cost of smelting merely rises as the iron content diminishes Some relatively low grades are now being worked The extremely low present cost of iron may thus be expected gradually to rise as lower and lower grade ores must be worked. Indeed, one of the principal advantages of the great Mesabi Range ore deposit lies in the low cost of open pit mining as contrasted to much higher costs that will be met when a larger share of our iron production must come from underground workings.

Magnesium is in quite a different category. Although originally produced from natural brines of more or less definitely limited extent, the metal is now being recovered from sea water (containing almost incalculably huge quantities of the metal but in great dilution) and from apparently inexhaustibly huge deposits of dolomite rock which is one of the major constituents of the Appalachian Mountains Perfection of present methods of recovery and their wider application appear to be all that is necessary to insure a perpetual supply of magnesium beyond any present expectations for its use

OBVIOUSLY, then, our post-war planning must include provision for the immediate improvement of our methods of producing iron and aluminum from more abundant sources; it must also include due consideration of the fact that only aluminum, iron, and magnesium are available for use in inexhaustible abundance for the long-time future.

The development of methods of recovering metals from low-grade ores is already well advanced It is no new thing. Steel companies for decades have realized that top-grade ores would some day give out, and have continuously directed their research toward meeting this problem. Also, it is worth while to note, iron ores are often chosen for exploitation for so simple a reason as the location of the deposit with respect to transportation facilities or even with respect to the surface of the ground itself because of the low price at which iron and steel must be sold.

Among the less plentiful metals, copper ore of first grade is becoming rapidly scarce. It is even likely that our post-war use of this metal may have to be seriously restricted to prevent a prompt rise of the base price of the metal to offset both its increasing scarcity and the higher cost of its recovery from more refractory or less concentrated ores. Zinc and lead seem still to be reasonably plentiful but our use of them must necessarily shrink in the long-time future

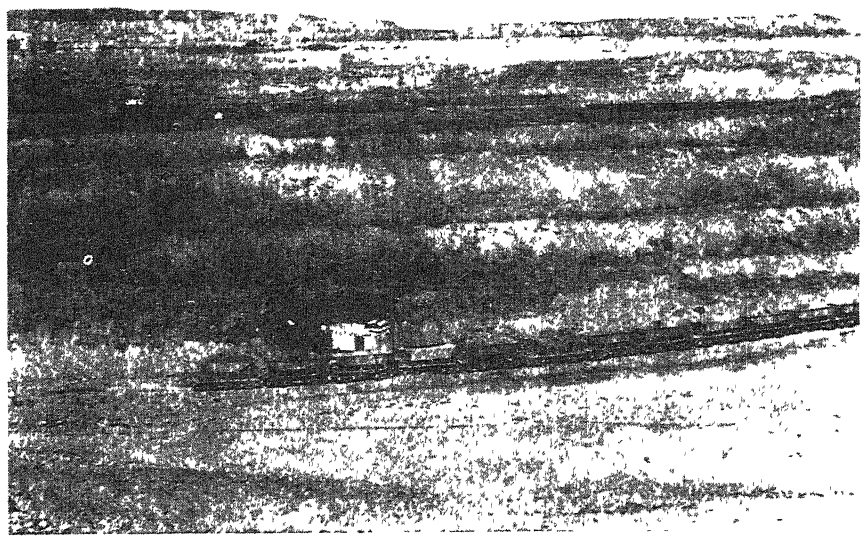
The case of tin has already advanced to a point where it shows something of what may be expected regarding other metals in the minor class. When supplies of this metal from the Far East were summarily stopped by the Japanese conquest of Malaya, restriction of its use followed immediately. Tin had been vital in several ways· tinplate, especially for cans; tin solders; tin for bearing metal and numerous other alloys including bronze, type metal, and others similarly useful; tin foils; and

Dow Chemical Company extracts magnesium from brine at this Michigan plant

collapsible tin tubes for paste products. Present developments include an electroplating method of applying tin continuously to steel strip at a saving of at least 50 percent of the tin required to afford protection; new solders containing much reduced quantities of tin or none at all, made with lead and silver; tin foils, even metal foils, seem definitely doomed by the efficiency of new synthetic and semi-synthetic sheeting materials; bearings plated with silver are proving extraordinarily efficient in high-speed applications and seem likely to prove permanently valuable. Meanwhile, a single smelter, operating on Bolivian ore in Texas supplies the United States' requirements of tin, now only a small fraction of its previous amount.

The relationship of iron and steel to aluminum and magnesium in commercial application must be kept clearly in mind in this discussion Present production of both light metals is less than 2 percent of current output of iron and steel. Obviously, then, many of the prospective uses for the light metals require development, probably over a long time, before their full potentialities are realized. Their complete future usefulness will not arrive suddenly with the coming of peace, as some appear to believe. Rather, in future decades they will occupy positions of constantly increasing importance in our economy.

Finally, the future role of plastics in relation to metals must be clearly understood. Despite their current high value in replacing metals for many purposes, plastics by their very nature are excluded from the great structural applications of metals. Even now emergency shortages push plastics only into minor items customarily made of metal. This, naturally, is in no wise intended to disparage these valuable synthetics, but rather to save them from their friends whose enthusiasm would apply them where they would surely fail.



In the Mesabi Range, dwindling source of richest iron ore

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SPEEDING PENICILLIN

Accomplished by High-Vacuum Dehydrator

A NEW high-vacuum diffusion process adapted to the drying of penicillin is believed to solve an important problem in processing the active germ-killing principle extracted from mold.

The 20- to 24-hour cycle now considered necessary for the last stage in processing penicillin can be reduced through this high-vacuum diffusion method to six hours, and the cost of dehydration cut to one-sixth of that of conventional methods.

A single installation of this novel dehydrator can handle ten billion units of this life-saving drug a week, far surpassing the output by methods now in use. Such an installation would make available 1300 doses of penicillin a day.

Penicillin is unstable in solution and hence dehydration is necessary to preserve it. Heat would injure the product and consequently dehydration must be done at low temperature in a vacuum. Heretofore, steam ejectors, mechanical pumps, and a freezing method utilizing a cold trap have been used on a limited scale in vacuum dehydration.

Penicillin is in a frozen state when it is dehydrated, the moisture being removed in vapor form without melting. Because of the enormous expansion of gases under the high vacuum employed, a pumping system of tremendous capacity is required to handle the great volume of water vapor formed. Some idea of this volume can be gained from the fact that an ice cube weighing one ounce represents at ordinary atmospheric pressure a little over a cubic foot of water vapor. At the low pressure involved in the new process, this ice cube expands into more than 25,000 cubic feet of vapor.

Freezing methods of vacuum dehydration have heretofore been handicapped by the building up of heavy ice layers in compartments designed to collect the vapor as evolved. Difficulties have also been experienced in attaining extremely low pressures. In the vacuum diffusion process, developed by the National Research Corporation, residual air pressures are reduced to less than one ten-thousandth of an atmosphere by special high vacuum pumps of tremendous capacity. The water vapor is continuously removed from the pumping system by means of a rotary condenser at very low temperatures.

In drying penicillin, as well as blood plasma and certain drugs, it is imperative that all moisture be removed. Extracting the last 2 percent of water vapor ordinarily has taken as much time and is more difficult than driving off all the rest of the original content. Since even minute amounts of moisture are harmful, proper drying and packaging are highly important parts of the process and have proved both costly and troublesome. Packaging in permanent containers is also done under high vacuum, to insure that no harmful moisture will be picked up.

GLASS OVERCOATS

Insulate Storage Batteries for Winter Use

GLASS overcoats are keeping storage batteries in working order in Army motorized equipment operating on the Alaska Highway and in the Aleutians. To prevent battery solutions from freezing when the temperature falls as low as 40 degrees below zero, Mid-West Fiberglas Fabricators is insulating the steel-box battery holders with half-inch thick boards of bonded glass fibers.

The glass fiber board, manufactured by Owens-Corning Fiberglas Corporation, has high insulating qualities, while resiliency of the glass fibers provides shock absorption and offsets any tendency to fragmentation or settlement under vibration.

POST-WAR SYNTHETICS

Will Invade Many New Fields

ONE OF the useful synthetic resins having rubber-like properties, Koroseal is expected to have important post-war applications in insect screens that can be rolled up like a curtain; water pipe that cannot be damaged by freezing since it is elastic; coated wall paper that can be washed when dirty; woven seats for garden furniture that resist weather indefinitely; and garden hose of lighter weight and longer life than customary rubber hose. These applications, announced by L. H. Chenowith of the B F. Goodrich Company, suggest the extraordinary versatility characteristics of the synthetics now replacing rubber in many of its uses.

Seeing is Believing

The Cathode-Ray Tube Comes Out of the Laboratory and Goes Into the Factory. Electrons were First Discovered and Their Characteristics Measured in the Cathode-Ray Tube; Now This Member of the Electron-Tube Family Performs a Large Number of Useful Industrial Jobs

STOCK demonstration apparatus used in all physics laboratories of a generation ago consisted of certain elongated glass tubes with metal electrodes in the ends, across which a high voltage was placed. Beautiful patterns called "glow discharges" were to be seen in these tubes, known as Geissler or Hittorf tubes. Out of these devices came our first knowledge of the electron and its properties; then came the Braun tube which developed into the modern cathode-ray tube which is the heart of television and other related apparatus widely used in the war.

The cathode-ray tube, long used only as a laboratory measuring instrument, now finds wide application in the production line for sorting machine-gun bullets, aircraft bolts, roller bearings, forgings, and other metal parts. Other non-laboratory applications are increasing rapidly to add luster to the already bright picture of electronics at work in industry

Just what, now, is a cathode-ray tube? How does it work? What makes it useful to industrial processes? Answers to these questions require a glance at fundamentals.

Consider a glass tube about a foot long and an inch in diameter. Metal disks are sealed into the ends and a vacuum pump is attached to an elongated glass stem. A comparatively high voltage is connected to the two electrodes. When the air is pumped from the tube, things begin to happen. As the internal pressure is reduced to about 500 to 1000 millionths of atmospheric pressure, current flows through the tube and each electrode is covered with a visible glow. At one half this pressure the glows extend out into the region between the electrodes but separated by a dark space. At still lower pressure the glows break up into striae or thin bands of light and the walls of the tube fluoresce. At 10 to 100 millionths atmosphere the glows disappear but the glass is bright and beautiful with fluorescence.

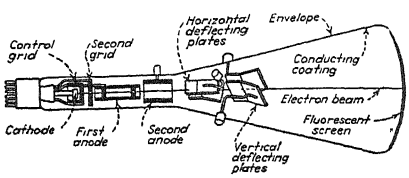
These phenomena naturally excited the interest and attention of many early scientists, who speculated among themselves as to what was going on inside the tube. Plücker is credited with the original discovery of the fluorescence of the glass walls in 1859. Hittorf observed that the "rays" traveled in straight lines from the negative electrode and at right angles to this electrode. By 1897, the date of J. J. Thomson's elegant research on the phenomena, it had been demonstrated that the rays could be deflected by electrostatic and magnetic fields; that an obstacle placed between the cathode and the glass wall casts a shadow on the wall.

Some physicists thought the rays were ether vibrations, like light, but in 1885 Perrin showed that, whatever the rays were, they had a negative charge. Finally, in 1897, J. J. Thomson demonstrated that the rays were particles which had a definite mass 1/1840 as heavy as the hydrogen atom and that they carried an electric charge equal to that transported by the hydrogen ion in liquid electrolysis.

The particles, of course, were electrons, but the phenomenon still bears the name of cathode "rays" originally applied to it The cathode part of the name arises from the fact that the electrons proceed from the electrode which is maintained at negative potential by the external current source, the negative terminal of electrical apparatus of that day and this is known as the cathode.

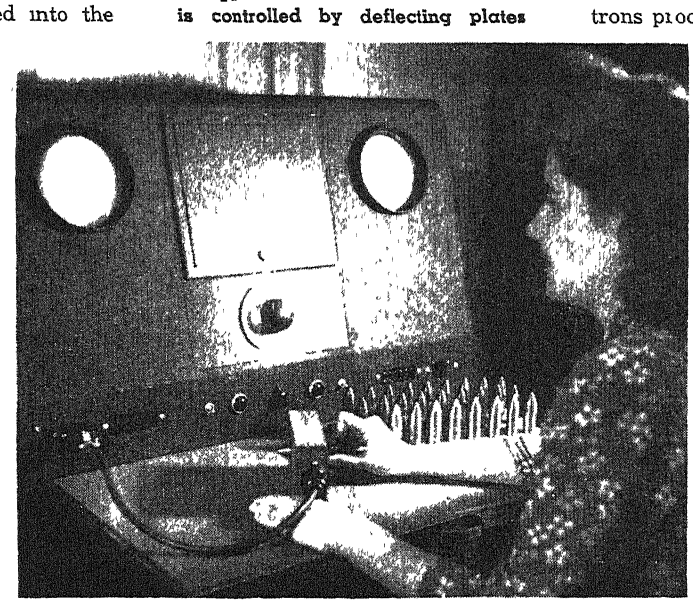
Thus the facts of life of the electron became known through the cathode-ray tube. Roentgen, experimenting with a tube of this type in 1895, discovered X-rays; soon Becquerel and the Curies discovered the natural phenomenon for which they are famous (radium) and the scientific world was off on another vast chase into totally new and exceedingly interesting facts Up to that moment scientists were pretty well satisfied; 'most everything had been explained and yet the ultimate nature of matter was one of the mysteries Out of the Geissler and cathode-ray tube came our vast knowledge about the building blocks of the universe

The present-day cathode-ray tube differs only in refinements from the tubes with which J. J. Thomson worked A source of electrons, which is merely a heated cathode like that in ordinary radio tubes, is at one end of an elongated glass envelope Along the narrow neck of the tube are placed electrodes in the form of small metallic plates. At the far end—which is flared out so it has a diameter as great as 20 inches—is a screen coated with fluorescent materials. When the electron leaves the cathode it is attracted toward the far end by a positive voltage; when it hits the screen its kinetic energy is given up to form a momentary flash of light.

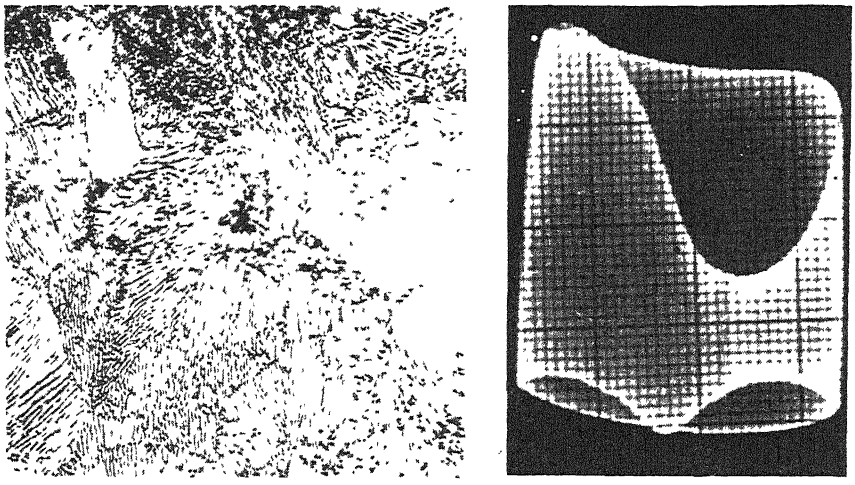


From "Engineering Electronics," by Fink, McGraw-Hill

Parts of a cathode-ray tube of the type in which the electron beam is controlled by deflecting plates



Testing hardness of steel in armor-piercing shells by inserting individual shells into a pick-up coil connected to the Cyclograph. Patterns appear on the cathode-ray tube screens



At left is a photomicrograph of the base metal of a shell which proved brittle on fracture test. At right is an electronic analysis of the same metal. Upper and lower curved sections change to indicate hardness of metals

If voltages are placed upon the deflecting plates in the neck of the tube, the place where the electrons hit the screen can be changed and if variable voltages are placed upon these plates, a definite pattern of light flashes will be traced on the screen For example, if the voltage on the plates varies from zero to some positive and negative values, the electrons hit the screen in a straight line and if similar voltages are placed on another set of deflecting plates at right angles to the first two, and if the proper phase relationships are maintained, a circle of light appears on the screen. Of course, the intensity of the spot on the screen can be adjusted by varying the accelerating voltage The size of the spot can also be changed at the will of the user

In television, the streams of electrons from the heated cathode are deflected back and forth in straight lines in synchronism with a similar scanning of the picture at the transmitting end of the system. After one line is produced, another similar line just below the first is formed. This goes on until the entire screen is filled with horizontal lines which can be exceedingly close together. If the intensity of the beam is changed at any point in the cycle through which the electrons pass in going from left to right, the fluorescence at the screen shows this variation in intensity. Thus a complete picture may be traced out on the fluorescent screen Since the electron is so low in mass, it can be deflected with great ease and rapidity so that the entire picture may be set up in a fraction of a second. Due to the persistence of vision, the eye sees the effect as a continuously moving picture

In the laboratory, the cathode-ray tube has many uses. The amount which the beam of electrons is deflected from its normal position in the center of the screen depends upon the voltages placed upon the deflecting electrodes. Thus the amount of deflection is a measure of voltage and can be so employed. Since the electrons may also be deflected by a magnetic field, it is not difficult to see that a varying current of electricity passing through a coil of wire adjacent to the neck of the tube will produce variations in the place where the electrons hit the screen and produce their fluorescence. In this way the tube can be used as a measuring device of current amplitude

Again it is worth noting that the electrons can be deflected in a millionth of a second or less, so that the characteristics of currents of extremely high frequencies can be studied. By placing a photographic film at the screen end, or by focussing a camera on the screen, a visible record of electrical phenomena occurring but once in a fraction of a second may be made. If the occurence can be repeated so that a steady pattern is produced, happenings at a rate of millions of times per second can be seen and recorded.

Now how can such an instrument be used for production testing?

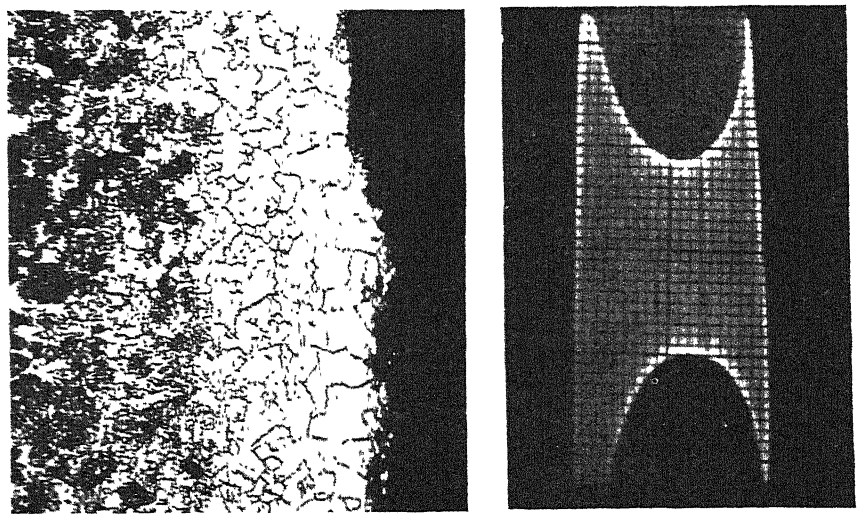
IF A PIECE of steel of certain desired characteristics is inserted in the deflecting coil of the tube, a pattern will be produced on the screen which may take, for the sake of simplified illustration, the form of a straight line exactly an inch long. Pencil marks may be made on the screen to serve as a guide If now another piece of steel is substituted for the standard, and it has somewhat different characteristics, it will produce a straight line longer or shorter than one inch. If the pattern indicates that it is outside the predetermined limits, the piece under test is discarded

An operator can make such tests very rapidly; in fact, much more rapidly than in most other ways. Since steel has electrical characteristics which change with variations in permeability (nickel content), in hardness, in density, in temperature, size or weight, all of these characteristics may be used as test factors Thus it may be desired to make bullets which are to have a certain weight so that they can be fired a certain distance up in the air. If they are too heavy, they will not go so high; if too light, they won't have the desired punch when they hit an enemy plane Such variations in weight will produce variations in an electric current in the coil into which the bullets are inserted, and the operator sees the result as a change in the desired screen pattern.

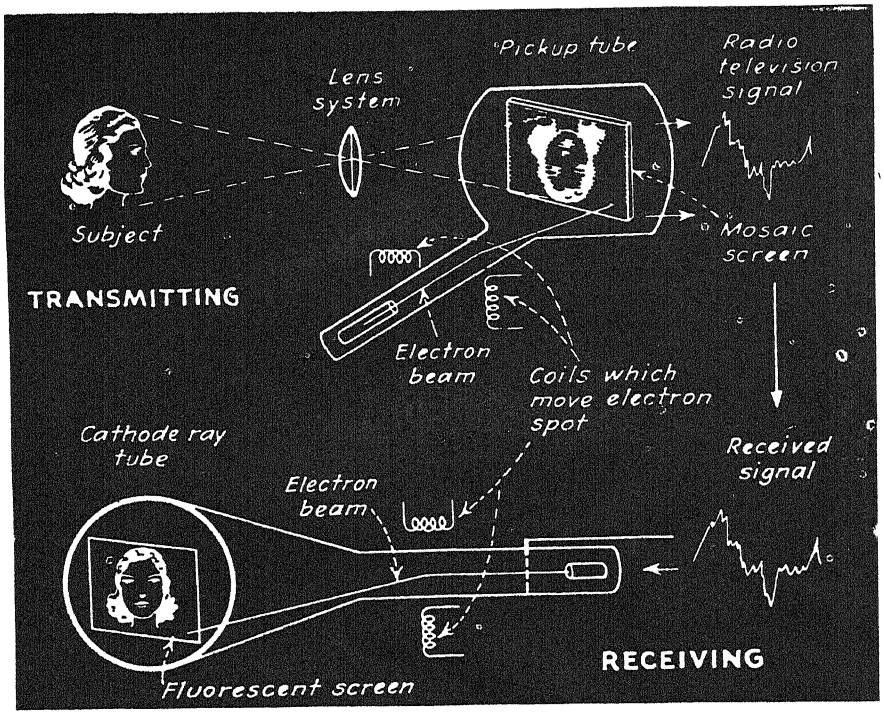
A cathode-ray instrument of this sort will detect changes in weight as small as 1/200 of an ounce. Also, since the permeability of steel is a function of the alloys in it and the heat treatment through which it has gone, the alloy content and the hardness can be easily and visually tested in the same manner

Working on this general principle, a testing instrument known as the Cyclograph has recently been developed by the Allen B. Dumont Laboratories

The Cyclograph is a cathode-ray instrument designed to perform both qualitative and quantitative metallurgical tests on both ferrous and non-ferrous metals, and adapted to facilitate the checking, evaluating, and sorting of these materials according to their metallurgical properties. This instrument has been developed to provide a non-destructive means of determining differences or variations in the metallurgical properties of metal parts or stock Some of these properties which have been investigated successfully include measurement of case depth, core hardness, plating thickness, carbon content, brittleness, and variations in the



At left is a photomicrograph of hardened steel, showing a case depth of about 0.020 of an inch. At right is a Cyclogram of the same metal. Each division on the screen is related to case depth and in this example the waist thickness (distance between curves of the ray pattern) indicates 0.020



Simplified set-up of a cathode-ray television transmitting and receiving system, using electron tubes in which the beams are deflected by magnetic means

results of various types of treatment.

The Cyclograph utilizes the principle that the metallurgical properties noted above cause variations in the core loss of a pick-up coil which surrounds the piece under test. These variations affect the shape of an easily interpreted visible pattern or oscillogram displayed on the cathode-ray tube indicator screen By means of these pattern variations, a semi-skilled operator can easily determine differences in metallurgical properties of a number of ostensibly similar parts

In addition to checking and evaluating metallurgical samples, the Cyclograph can also be adapted to automatic sorting. This automatic sorting feature is invaluable where large quantities of samples are involved, as in actual production and production-test routine. Such automatic sorting is done accurately at relatively high speed—as high as five pieces per second.

Some representative practical examples, typical of the various kinds of sorting which have been done with the instrument, are:

1. Several million aircraft bolts were successfully separated into three groups with analyses of SAE 1020, SAE 4130, and SAE 1065.

2. Three hundred tons of 1 21/32-inch billets were sorted into the two analyses present, in eight hours. The Cyclograph was taken to the mixed billets. One end of each billet was lifted in a sling and the coils slipped over the end to test the billet

3. Eight thousand cylinder-head bolts were sorted in one day into the two analyses present. The analyses were SAE 1035 and SAE 1335.

4. Several thousand machine-gun bullets were successfully sorted. The only difference in analyses was that one group contained no nickel while the other contained 1.5 percent nickel.

5. Ten thousand small bolts were automatically sorted in a few hours. The bolts were of the same analysis, but some had been quenched and drawn, while the rest had only been quenched.

6 A large number of roller bearings were sorted according to case depth Those which had too thin a case were separated from the others and rejected.

While the functions of weight checking and metallurgical testing have been dwelt upon here at length as being the latest achievements of the cathode-ray tube in industrial production applications, there are many other practical uses of this versatile instrument. These include testing electrical response of transformers, resistors, or other components, magnetic characteristics of laminated materials, insulation between turns in motor armatures, conductivity of chemical baths, and so on.

In fact, any variable, whether it is electrical, chemical, or physical, which can be translated into an electrical change, can be made to produce on the cathode-ray tube screen visible patterns which are easy to see, relatively untiring to look at, and which accurately portray the change being studied—all without damaging in any way the material under measurement.

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X-RAYS IN NEW USES

Ability to "See Through" Opaque Objects Used by Food Packers

USES OF industrial X-rays are, by now, an old subject. Nearly everyone knows that X-ray technique enables an industrial engineer to look into a heavy casting and see whether there are flaws in it But still the ability to see the inside structure of opaque objects by means of X-rays is finding many more uses.

For example, food is now automatically packed in all manner of containers. Manufacturers and packers are continually liable to heavy damage suits if in such a container there is a drop of solder or a piece of machinery which may have dropped off the packing or cutting apparatus This is a constant worry and it is much greater at the present moment when so many thousands of cans of food are going to the armed services.

By a simple X-ray apparatus equipped with a fluoroscope, it is now possible to look into the inside of every can or jar or carton and to reject those which contain unwanted material—even if only pieces of bones

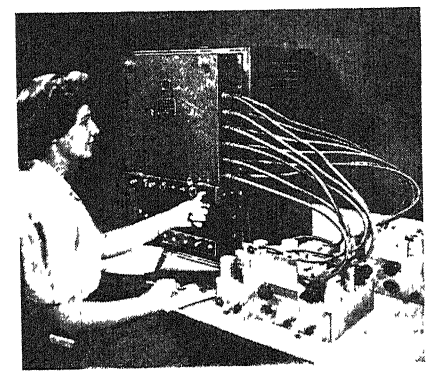
The post-war market for X-ray apparatus will be materially increased by just such simple, yet extremely effective uses as this.

HIGH-SPEED CIRCUIT TESTER

Checks 120 Circuits In 4 Minutes

A RECENTLY developed automatic mass-production tester employs electronic tubes in a measuring circuit served by an ingenious motor-driven selector switch to permit checking of circuits in electronic, communication, and electrical equipment at the rate of one circuit per second.

The instrument, made by Communication Measurements Laboratory, reveals errors in resistance and reactance



Using automatic circuit tester

as well as in circuit wiring. Once this almost robot-like instrument has been set up for checking a particular piece of equipment, its operation simply involves making connections between the tester and selected points in the equipment under test, then pressing a button and watching the indicator light. When an error is detected by the instrument, it stops so that the operator can record the number assigned to that particular test and thereby locate the fault. Pressing a button starts the machine again for completion of the sequence of tests.

A recent application involves checking of multi-wire cable harnesses for aircraft, tank, and switchboard wiring. Up to 120 circuits, including several hundred separate wires, may be tested at one time in about four minutes.

Air Transportation—A Review and Forecast

Views of Men Outstanding in the Aviation Industry Serve to Present a Picture of What is Being Done Today and of the Effects of these Efforts On the Post-War Transportation World. Air Cargo, Safety, Gliders, Local Air Service, Airports and Airways, All are a Part of the Whole

At a recent Air Transport meeting, held by The Institute of the Aeronautical Sciences and attended by officers of the Air Transport Command as well as representatives of the airlines and of airplane manufacturers, the papers delivered by outstanding men in the industry covered the whole field of American air transport. Aviation people are giving their strength to winning the war; yet, in the light of recent events, it is impossible not to give some thought to the future, and this meeting may well serve as a guidepost for post-war air transport.

The Air Transport Command has probably had more experience with air cargo than any other organization in the world. Hence the paper presented by Colonel Harold R. Harris, Assistant Chief of Staff, A.T.C, entitled "Some Problems Encountered by Air Transport Command in Handling and Movements of Air Cargo," was received with intense interest.

In December 1941, the Army Air Forces found itself saddled with an enormous air-transportation problem, world-wide in scope. Almost the only service-tested transport plane then available was the DC-3, widely used by the airlines and in which many of our readers have no doubt flown. Rapid conversion of these ships to cargo carrying was undertaken and accomplished by the simple expedient of stripping out passenger fixtures, installing cargo equipment and strengthening the cabin floors. To this day, the Douglas DC type aircraft is a most important part of the Air Transport Command fleet, with wide double doors added for more efficient handling of cargo

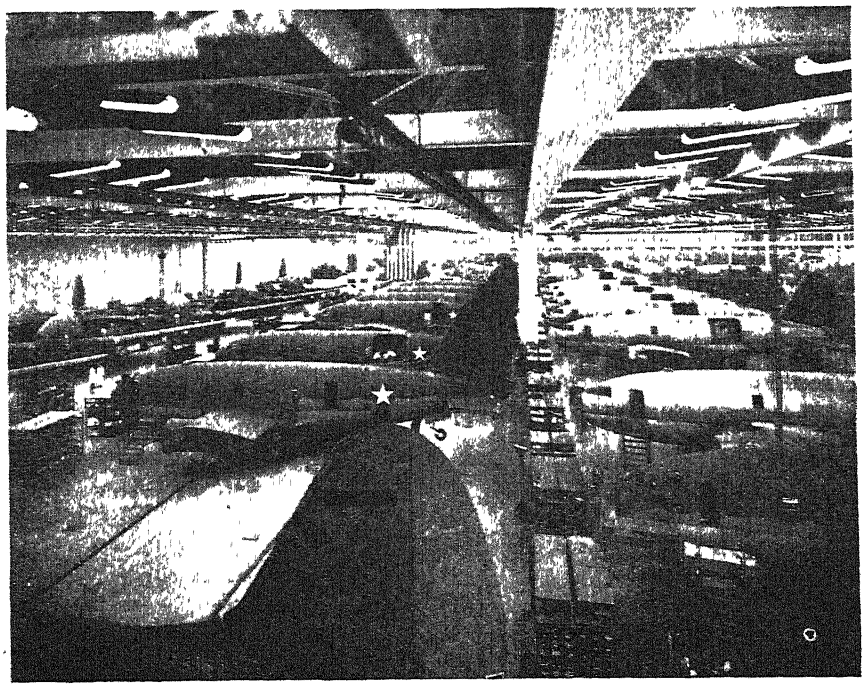
Several Boeing Clippers and Boeing Stratoliners were also put to work, and. soon after, a large four-engined plane, the Douglas C-54, was added The Consolidated B-24 Liberator bomber was then converted to cargo use, and is giving fine service as the C-87. A new transport type coming into widespread use is the Curtiss Commando, or C-46, well adapted to cargo work with its wide doors, large cabin dimensions, tie-down rings, good flying characteristics. Just over the horizon is the Lockheed Constellation, largest transport yet designed. The Army has operated these craft, not always suited to its purposes, in every range of temperature, humidity, and weather.

Military cargo is now traveling by the northern route to Great Britain; by the southern route to Africa, the Middle East and the Far East. The Central American route brings the Panama Canal to within a few hours of flight.

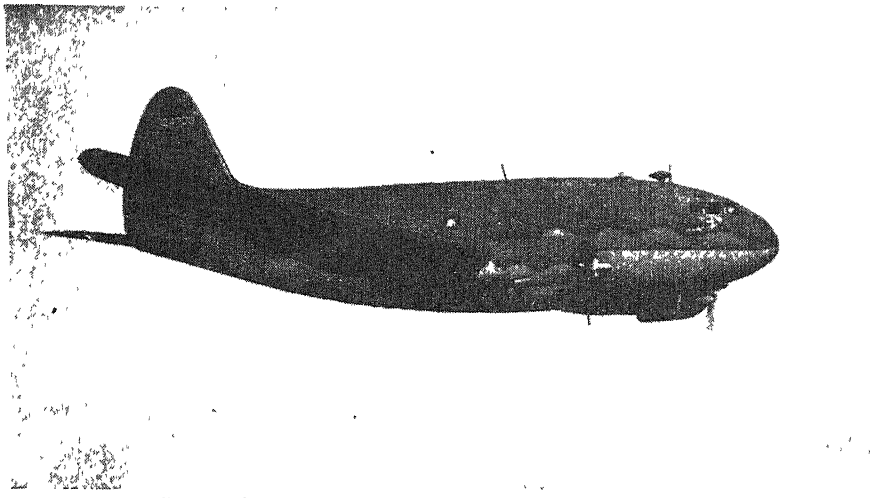
Aircraft engines, bulldozers, oil drums, barrels of cement, are carried as a matter of course. As distinct from heavy cargo, odd-shaped pieces are not so hard to move into the airplane, but steel pipes and bars, propeller blades, wing tips, aircraft cowling, and ailerons are difficult to stow and tie down Some of the cargo can be packed in containers of conventional size and shape, other cargo requires special handling in stowing and tie-down, as in the case of explosives. Serums and some other types of medical supplies require icing.

Of the above problems, that which has occupied the Air Transport Command most is the tie-down. The objectives of a good tie-down are not simple. Ease of loading and unloading, positive securing of cargo within the cabin, and economy of material used must all be considered and these objectives are not easy to achieve At first, the Army turned to rope, but rope stretches, knots slip, and sometimes knots are cut with a knife, wasting valuable material

It was interesting to learn from Colonel Harris that the research facilities of commercial organizations had, after much experimentation, developed improved methods of cargo tie-down All A.T.C cargo aircraft are now being equipped with a system utilizing vertical bars inside the cabin to which horizontal cross-beams are anchored over the top of the cargo Locks are slipped over the bars and jacked down over the cross-beams. The jacks are simple but powerful and insure ample pressure on the cross-members so that the cargo is firmly held The vertical bars are held in floor rings fastened to the structure of the airplane The locks can be instantly released and an entire tie-down dismantled in a few minutes Rope still plays an important part but only in securing light, unsymmetrical pieces, standard lengths being used with previously attached hooks so that knots are largely eliminated. Heavy wire tighteners in the form of levers take up slack and provide adequate security



Curtiss Commandos on the assembly floor. Note wide doors



A Commando transport in flight. Now "coming into wide use"

The Air Transport Command has shown how air cargo can be handled under great difficulties, its lessons will not be lost on commercial operators

One of the recognized authorities in the field of airline engineering operation, William Littlewood, Vice-President in charge of engineering of American Airlines, discussed "Realistic Air Transport Planning" at the meeting Of late, ambitious and even fantastic projects have been announced on all sides, and Mr Littlewood did the industry a service by bringing matters to a more prosaic level. Careful planning has to be undertaken, with consideration of reasonable schedules as well as adequate capital, revenues, and facilities for air navigation and the like

THE SPEAKER pointed out that there was grave doubt whether some of the very ambitious undertakings described in the press could be realized It is all very well to draw lines on a map to indicate flight lanes across the polar caps, but there were many problems in cold weather flying that have not yet been solved.

Then, too, the helicopter still had to demonstrate reliability in day-to-day service and in cargo carrying Floating seadromes across the Atlantic are a magnificent conception but no one knows how safe they may be or how economically feasible

Speaking of the airplane equipment which would be available at the end of the war, Mr Littlewood again voiced a word of warning. On the whole, it may be a year after the termination of the war before airplanes now in service can be converted for transport operation, and it may be two or three years before entirely new airplanes are available. Instead, therefore, of counting on fundamentally improved equipment in the immediate future, it would be better to see what can be done first with equipment of the type now available.

For passenger carrying, it is absolutely essential to have two engines and to be able to fly on one engine only. This is a great measure of safety, but, on the other hand, it is also an economic penalty. It is just as possible that, for cargo carrying, the Civil Aeronautics Administration may permit the use of a ship with only one engine and pilot.

In general, it would appear that the larger the airplane, within limits, the better its payload capacity. A prognostication may be drawn, therefore, that for a given route, as large an airplane as possible will be used, provided its capacity does not exceed the traffic demands of that route In the immediate future, however, a maximum passenger carrying capacity of some sixty passengers may be expected.

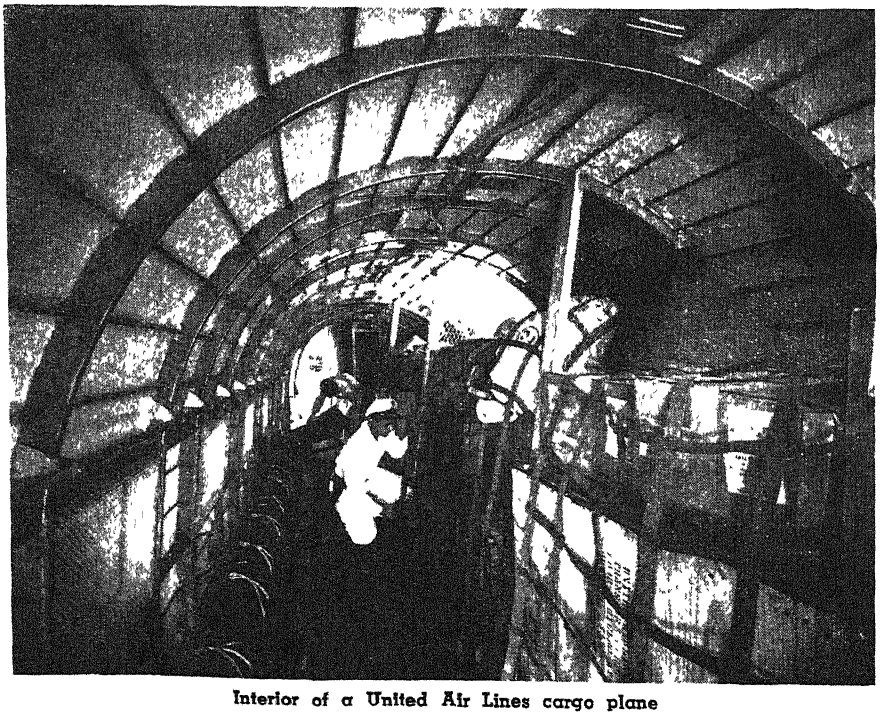
Railroads, generally speaking, run their fastest trains across the continent and their slower trains in suburban traffic Mr Littlewood stated that with the airplane the reverse would be logical. For short range, the very fastest planes are necessary to balance loss of time in loading at the airport

The subject of gliders in military use and air transportation was discussed by Grover Loening, Consultant on Aircraft for the War Production Board While hampered by the necessity of military secrecy, Mr Loening gave a remarkable picture of progress in the efficiency and serviceability of the glider. The pick-up system for these gliders has been developed to an extraordinarily successful degree, particularly in the hands of the late Richard C du Pont Gliders can be taken up by an aerial tug in flight and released over a given field. The air train is a decided possibility and may become one of the most important fundamentals of air transportation in a few short years It would permit an enormous amount of cargo to be carried at relatively slow speeds, it would give greater versatility to air transportation; it would allow some of the smaller cities to be more adequately serviced from the air

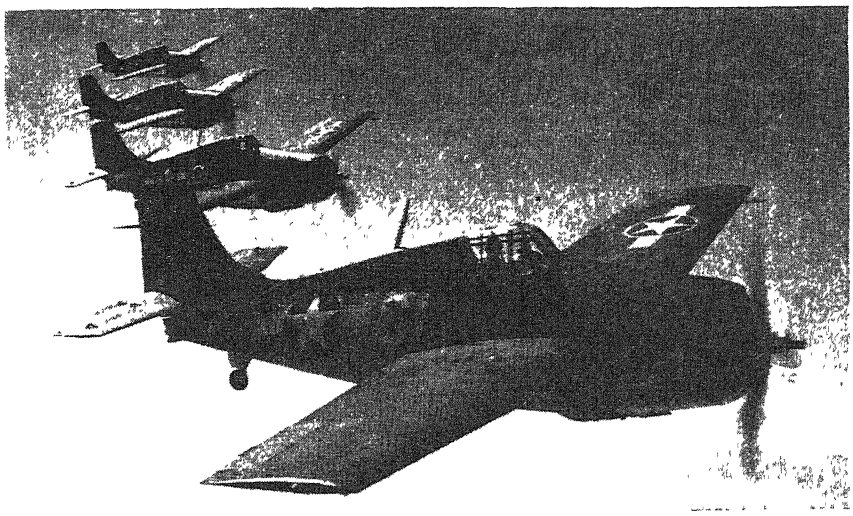
THE DISTINGUISHED Vice-Chairman of the Civil Aeronautics Board, Edward P Warner, stated that 64 percent of the people of the United States now live within about one hour's highway traveling distance of one or another of the points now certificated to receive air transportation But, to take advantage of this situation, the number of stops on air-transport routes would have to be increased from the present 284 to 1600 so as to reach the bulk of such population.

Before the war the degree of public experience with air transportation was not great enough to support more than a few local services operating under the best possible conditions, but the present popularity of air transportation should make it possible to run a larger number of local services after the war. Mr Warner said it would be reasonable to increase the number of airline stops to about 3400 The air route mileage within the United States would then grow to about 200,000 miles and the flying of about 750,000,000 airplane miles could be expected, which would be considerably more than the present annual passenger-train mileage of the railways of the United States.

The organization of the Civil Airways of the United States was described by William A. M. Burden, Special Aviation Assistant to the Secretary of Commerce, who has made a splendid repu-



Interior of a United Air Lines cargo plane



A surprise for the Japs: The new Hellcat resembles the Wildcat

tation for himself as one of the most far-sighted aviation men in Washington. The 35,000 direct route miles of the airways system is divided into 23 geographical units, the traffic in each of which is controlled from a central office Passenger movement had increased from 150,000 in 1937 to over one million by 1939 During 1942, six and a quarter millions were handled and it was conservatively estimated that this might increase to twenty millions per year by 1950

The Civil Aeronautics Administration is making plans to handle this extension of traffic, particularly as regards communication. A new ultra-high frequency radio range eliminates the effects of weather, static, fading signals, and other shortcomings of the present radio range. When the C A A establishes the airways system using the new radio range, direct routes, approximating great-circle routes, will be provided between large terminals and the air space will be stratified It is probable that shorter city-to-city traffic will continue to operate on the present type of airways system at lower levels As routes are added, procedures will be devised to permit aircraft to enter or cross principal airways at specified points. Long-haul traffic will by-pass points of congestion. Long-distance traffic above 12,000 feet will be directed by automatic direction-finding equipment and ocean traffic may be similarly handled. Anti-collision devices already developed will provide greater safety

It was predicted by Mr Charles B Donaldson, Director of Airports of the Civil Aeronautics Administration, that there will be 300,000 private aircraft in operation within a few years after the war. To meet this enormously increased traffic, plans for airport development are being revised on a tremendous scale. Nor will airports always remain the same. John C. Leslie, Manager of the Atlantic Division of Pan-American Airways, in his paper "Effect of Airport Operating Characteristics on Airport Runway Patterns," presented some novel ideas on the design of airports. To meet the ever-growing traffic, long runways might be parallel or multiple, they might diverge or converge, they might form a triangular pattern or be tangential to a circle at the field's center.

Discounting the fact that the papers thus briefly reviewed were read by aviation enthusiasts, there still emerged from the meeting a definite feeling that one may well expect after the war a tremendous extension of air transport, both passenger and cargo, that private flying would keep pace with it, and that, keeping pace with increased flying, there would come increased airway and airport facilities

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CARGO STOWING

As Developed by United Air Lines

It is not the Air Transport Command alone which is carrying cargo by air. United Air Lines has inaugurated a coast-to-coast all-cargo schedule for essential war-time mail and express. Planes leave San Francisco and New York daily at 12.30 A M The San Francisco-bound planes reach that city at 5·46 P.M. the same day and the New York-bound planes arrive at La Guardia Airport at 9.46 P.M. on the same day. The difference in speed is only apparent, and is explained by changes in time.

The ships employed are the well tried Douglas DC-3s, which will carry about 6000 pounds of express.

One of the illustrations in the preceding feature article shows the manner in which the luxurious passenger ships have been converted to cargo use. They have been stripped of furnishings and equipped with special cargo features such as plywood floors, plywood siding, steel screened windows, cargo bins, and means for holding cargo in place by the use of wire mesh compartments and flexible straps tied down to rings on the floor and sides.

THE HELLCAT

Has Great Combat Advantages Over the Wildcat

The UNITED STATES NAVY now has the two finest shipboard fighters in the world; one is the Grumman Hellcat, the other is the Vought Corsair The design of the Hellcat, which succeeds and surpasses the Wildcat, came from a happy combination of the practical knowledge of fighting pilots and the great engineering skill of Grumman engineers. In fact, that is the way all combat airplanes should be designed No Government, however well informed, no group of engineers, however skilled, can build effectively without tapping the knowledge of pilots who have actually fought.

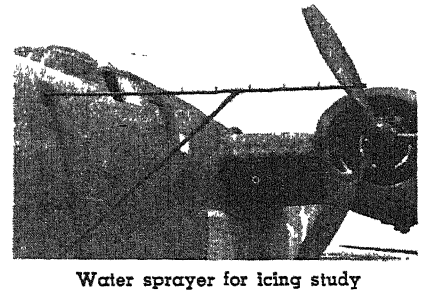
The Hellcat, as seen in the photograph, has many of the well-known Grumman features, such as the square wing tip; it also has more armor, more firepower, heavier guns, and all other necessary equipment and much more power than the Wildcat. As a result, it has the good qualities of the Wildcat plus more range, more speed, faster climb, and above all, more maneuverability. The Hellcat has a remarkably short turning radius and better visibility is obtained by pitching the engine cowling down so that the pilot can see over the nose of the fuselage when training his guns on the enemy

It has been pointed out, with malicious pleasure, that the Hellcat can be easily mistaken for the Wildcat, and that the Japanese must have received some very unpleasant surprises when the new fighter first appeared

ICE FORMATION

Now Studied Under Flight Conditions

The MATERIEL COMMAND of the Army Air Forces reports an ingenious method of studying ice formation on the propeller in flight, by means of the system illustrated in these columns On the B-24 Liberator Bomber an outrigger is installed leading from the fuselage to a point ahead of the inner propeller blades. Water stored in tanks located in the bomb-bay of the ship is sprayed into the propeller while the plane is in flight, and a camera installed inside



Water sprayer for icing study

the plane is pointed at the propeller through a specially built window. The shutter of the camera is synchronized with the propeller speed, so that the propeller appears to stand still and detailed photographs of ice formation can be taken. From such photographs the engineers learn of the character and rapidity of ice formation, and subsequently can study the remedies applied, such as slinging of anti-ice liquids, heating of the propeller, or whatever else may suggest itself

Ultra-Low-Melting Alloys

Peculiarly Fascinating is the Group of Alloys that Melt at Hot-Water Temperatures. Such Alloys are Now Wholly Engaged in War Work, Doing Jobs that Will Surprise Many and which Forecast an Extended Post-War Utility

BISMUTH as a common ingredient of antiseptic or stomach-sweetening drugs is well-known to millions of Americans, but as the basic constituent of a group of industrially important alloys it is less renowned. This situation fails to reflect the large increase in the use of bismuth for metallurgical purposes that has occurred since the war production program started, also the changed proportion of metallurgical to other uses of this interesting metal.

Actually the non-pharmaceutical uses of bismuth, which once represented less than 20 percent of its tonnage consumption, will require more than half of all the two and a half to three million pounds of bismuth produced in this hemisphere this year. Most of these non-pharmaceutical uses are metallurgical, and the most important of the latter are those filled by a group of bismuth-base alloys especially developed for their very low melting temperatures, their expansion or virtual freedom from shrinkage on solidfying (permitting sharp reproduction of surfaces against which they are cast), and their usefully high strength and hardness when set.

These applications have been established within our currently most vital industries—aircraft, ordnance, machinery, and electrical parts particularly. In the aircraft manufacturing field the use of low-melting bismuth alloys for fixture work, forming dies, tube bending, and anchoring has become commonplace. These, when added to other uses developed in other fields and to new applications, some with brand-new alloys, still in the experimental stage, provide a foundation on which an important post-war structure is expected to be built.

The description "low-melting-temperature" most commonly used to designate the chief characteristic of these alloys is, of course, relative. Bismuth alloys are, however, *really* low-melting, many of them being liquid at temperatures below that of boiling water (212 degrees, Fahrenheit). Some are so low-melting that a startlingly accurate replica of the palm of a hand can be produced *without discomfort* by spraying it with a molten bismuth alloy.

In the accompanying table are presented recent and accurate data on the compositions and corresponding freezing ranges of the most important bismuth alloys in commercial use today. These data are supplied by the Cerro de Pasco Corporation who pioneered the technical development and commercial application of bismuth alloys especially compounded for specific jobs, and are in fact the only large company in this country manufacturing a series of standard trade-named bismuth alloys (Cerromatrix, Cerrobend, Cerrosafe, Cerrobase, and so on).

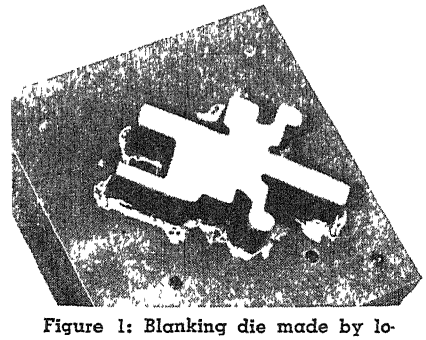


Figure 1: Blanking die made by locating and mounting the working section in a low-melting alloy

The low-melting temperatures of bismuth-base alloys has made them the traditional choice for such applications as electric safety devices, safety plugs in compressed gas cylinders, and fusible elements in sprinkler heads, fire-door releases, and so on. But a long list of new uses has been found within the last few years that depend not only on the low melting temperatures of the alloys, but on their "growth" behavior.

The growth behavior is interesting enough to merit some explanation. Most molten alloys, when allowed to solidify in a mold, undergo a certain amount of contraction or shrinkage in the process. This is responsible for the shrinkage cavity or pipe in a steel ingot, and also for the difficulty in reproducing fine mold details in a casting made of iron, brass, or aluminum, since the solidifying metal tends to shrink away from the mold surfaces as it freezes. Many of the bismuth alloys, however, actually *expand* on freezing—thus assuring the most accurate reproduction of the surface against which they are cast—and then continue to expand slowly in the solid state for many hours after reaching room temperature

This tendency to expand for some time after solidifying—(one bismuth alloy, for example, grows 0 005 inch per inch during the first 13 days after casting)—improves the "anchoring" quality of these alloys; that is, their ability to grip notched, keyed, or bossed surfaces on which they are cast or to fill tightly annular spaces despite the absence of any fusion bond with steel, iron, brass, bronze, wood, and so on

Typical of the advantages of these alloys are those found in making complicated dies and punches. To machine the punch or projecting die face out of solid tool steel is always extremely expensive, and in addition the subsequent hardening is certain to introduce distortion of the working surfaces that may be costly or impossible to correct. The modern practice is to produce the dies and punches in simple, easy-to-machine sections and then mount them in low-melting alloy. The wasteful machining of non-working surfaces is avoided; the simpler shapes can be hardened individually and any distortion easily corrected on each; and the die parts can finally be located in relation to each other with extreme accuracy during the mounting.

All this is clearly demonstrated in the case of the blanking die, shown in Figure 1 The parts of the die are secured to the base by Cerromatrix, a strong, hard alloy of bismuth, lead, tin, and antimony that begins to soften at 219 degrees, Fahrenheit, and is completely molten at 440 degrees, Fahrenheit The temperatures used are too low either to distort the die sections or to draw their hardness

Dies constructed in this way have given service and life on a par with those made by other methods and at only a fraction of the latter's cost Sectional dies, lamination dies, perforating dies, and compound (piercing and blanking) dies also have been found especially amenable to this type of construction.

The use of the matrix alloy for anchoring stationary parts of machines has rapidly expanded in recent months. It has been found particularly useful for mounting bearings and bushings that must be located with the utmost accuracy in relation to their shafts. The problem is very simply solved by providing an oversized hole for the bushing, accurately aligning the latter in it, and then securing it in place with the matrix alloy. Experience has revealed

a subsidiary advantage of this arrangement—overheating of the bearing through failure of the oil supply results in melting of the inexpensive matrix alloy before serious damage is done to the expensive bushing

Allied to these applications is the use of the matrix alloy for making chuck jaws for holding irregularly shaped pieces during machining. The finned die casting in the center of Figure 2 is a good example of such a problem. To machine-out a suitable set of chuck jaws for this part in the usual way would be prohibitively expensive, so a low-melting bismuth alloy (Cerromatrix, again) was cast against it inside a two-part retaining shell of brass

Another recent chuck application of bismuth alloy is for separating the pole piece on *magnetic* chucks The bismuth alloys are electrically ideal for such use, since they are among the most diamagnetic materials available; the "expanding" property provides a water-tight fit; and the low pouring temperature permits previous case-hardening of the pole pieces, which thus have improved wear resistance.

SHORT-RUN sheet metal stamping and forming dies represent another field that these ultra low-melting alloys have invaded in recent years. The matrix alloy die may be used with a rubber punch, the matrix alloy may be employed for both the die and punch, or a matrix alloy die may be used in conjunction with a punch made of a lower-melting bismuth alloy.

In Figure 3 are shown a light-gage stainless steel airplane part and the bismuth alloy punch and die used to form it The die is made of Cerromatrix and the punch of Cerrobase (the eutectic alloy of bismuth and lead, which melts sharply at 255 degrees, Fahrenheit). A replica of the punch was first made in a plaster composition and became the pattern against which the matrix alloy die was cast. This casting then served as the mold for casting the lower-melting Cerrobase punch.

The aircraft industry has been a heavy user of another bismuth-base alloy—a controlled version of Wood's metal, known as Cerrobend and designed especially as a filler for bending the tubing used so lavishly in that industry. This alloy contains bismuth, lead, tin, and cadmium in eutectic proportions and melts at the very low temperature of 158 degrees, Fahrenheit. Among its most useful properties are the family traits of expanding on solidifying and its ability, as one engineer put it, of passing through a hole "finer than a frog's hair."

Obviously, if one attempts to bend a thin-walled metal tube around a small or medium radius, it will buckle or flatten. To overcome this such fillers as rosin, sand, pitch, lead, solid mandrels, and so on have been placed inside the tubes to make them behave in bending like a solid bar None have been found so satisfactory from the standpoints of convenience, production-speed, accuracy, and safety as the bismuth alloy

Its application is simple: The fully-annealed, internally-cleaned and oiled tubing is plugged at one end with a rubber or hardwood plug, and then filled with molten bismuth alloy The tubing is quenched to solidify the filler alloy, rewarmed somewhat, and then bent with a slow uniform pressure over a forming block or in a bending machine. The bent tube is placed in a tank of boiling water to melt the filler alloy, which is then poured out and the tube quickly cleaned inside. The tendency of the alloy to run through pores or "heave" surface defects aids in revealing flaws in the tubing.

Bismuth alloy has been applied to the bending of aircraft tubing made of all the usual materials. Tubes of irregular section can be bent as readily as round tubes; one of the most interesting applications is the edgewise bending of rectangular molding by combining two pieces to make a single rectangular tube, filling with bismuth alloy, and bending.

Another development within the aircraft industry is a new kind of metal-clad manufacturing fixture that depends for its success on the use of bismuth alloy. The Castaloy Corporation has employed these low-melting materials (chiefly Cerrobend) to make metal model replicas, gages, assembly fixtures, spotting fixtures, and so on, that assure complete interchangeability of parts whether made by a prime contractor or by one of his numerous sub-contractors. Such perfect interchangeability not only speeds production but simplifies field service.

In practice a master model—(perhaps the part itself or a plaster cast or mock-up)—is employed as a dummy, from which a bismuth alloy template, an alloy-clad wooden template, or a frame-type or skeleton fixture with the working points faced with bismuth alloy is prepared. Once the original model or fixture has been approved it is a simple matter to duplicate it in as many bismuth alloy—(solid or clad)—fixtures as are required.

The method saves many operations and much time. One plane plant, for example, reports that its use saved about half of the time normally required to obtain cowling tools, parts, and assembly fixtures, and in addition permitted design flexibility not otherwise possible.

Of considerable post-war interest is the variation of this principle illustrated in Figure 4—a bismuth-alloy-clad wooden template used in conjunction with a forming punch for making automotive roof panels. By this method several dies for different panels can be made simultaneously from the original fitted templates, with assurance of perfect fitting, instead of having to be made in succession and individually fitted, as before.

A very recently developed bismuth alloy (known as Cerrosafe) is being extensively used for accurate proof casting of molds, gun chambers, forging dies, and so on. The new alloy melts above 165 degrees, Fahrenheit, (its freezing range is actually 190 to 160 degrees, Fahrenheit) and contains bismuth, lead, tin, and cadmium. It shrinks ever so slightly during solidification and cooling to room temperature, returns to its original dimensions in the next 50 minutes and grows very slowly thereafter.

The new alloy is also being used as a sprayed-on coating for protecting wooden patterns and core boxes used in foundries. The protection not only extends the life of the pattern several-fold but also eliminates distortion resulting from moisture absorption.

In addition there are a host of developing applications for these ultra-

Composition and Melting Temperatures of Some Bismuth Alloys

Yield Temperature, Degrees Fahrenheit	Freezing Range, Degrees Fahrenheit A—B	Composition, Percent				
		Bismuth	Lead	Tin	Cadmium	Others
119	129-119	39 00	20 80	10 40	7 80	22 00 Indium
140	154-131	42 00	21 00	10 50	10 50	16 00 Mercury
153	223-131	35 60	49 10			15 30 Mercury
158	158-149	47 50	25 40	12 60	9.50	5 00 Mercury
158	158-158	50 00	26 70	13 30	10 00	
162	174-158	50 00	34 50	9 30	6.20	
163	194-158	42 50	37 .0	11 30	8 50	
171	207-158	38 40	30 80	15 40	15.40	
197	197-197	51 60	40 20		8 20	
203	203-203	52 50	32 00	15 50		
203	289-203	50 00	25 00	25 00		
208	271-203	46 10	19 70	34 20		
214	244-208	40 00	40 00	20 00		
217	217-217	54 00		26 00	20 00	
223	441-217	48 00	28 50	14 50		9 00 Antimony
223	280-217	40 70		27 90	31 40	
226	271-207	36 50	36 50	27 00		
234	241-225	54 40	43 60	1 50	0 50	
241	246-232	54.40	43.60	2 00		
255	255-255	55 50	44 50			
275	275-275	57 40	1 00	41 60		
280	280-280	58 00		42 00		
291	291-291	60 00			40 00	

The "yield temperature" of a fusible metal is the temperature at which the fusible metal or alloy will yield, or melt, as determined under conditions specified in bulletin File 122 of the Compressed Gas Manufacturers' Association, Inc., New York
Freezing range (A) formation of crystals, (B) completely solidified

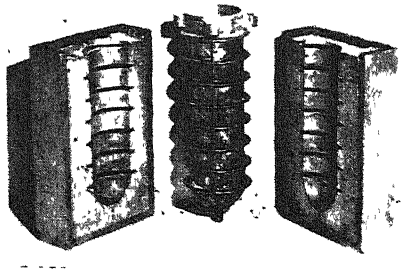


Figure 2: Cast bismuth alloy chuck jaws (left and right) hold the part (in the center) during machining

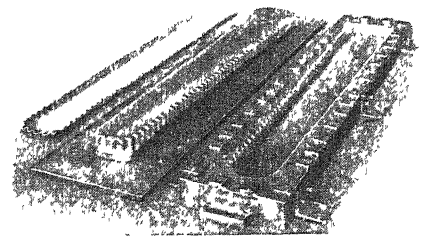


Figure 3: Two different bismuth alloys are used for this punch and die set for forming aircraft parts

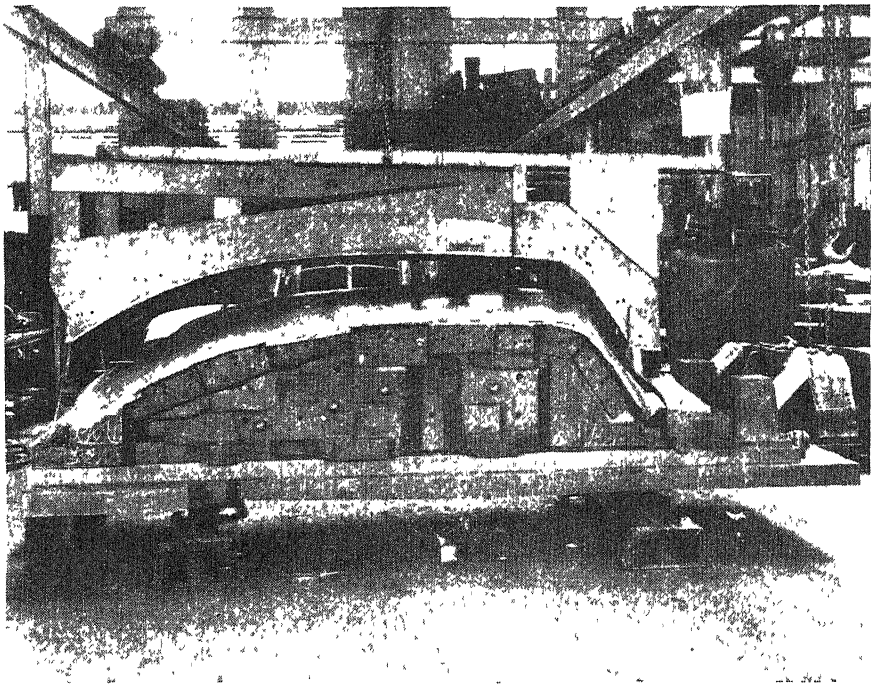


Figure 4: Forming an automobile roof panel on a bismuth alloy-clad punch

low-melting alloys that can only be mentioned but which may hold the spotlight when peace returns and the bismuth alloys can again be made available for civilian uses. One of them is as conducting, but subsequently easily removable, cores on which metals are electroformed for various purposes One company is now electroforming a copper Pitot tube using a cast bismuth alloy cathode core, with internal baffles and protruding heater parts inserted in the original mold.

One of the newest developments is a bismuth alloy (called Cerrotru) that shows no *measurable change in volume* while passing from the molten state to the solid condition and on aging. This means complete absence of piping and perfect reproduction of mold detail.

The ultimate in low-melting temperatures has yet to be reached At present, bismuth base alloys containing indium are being studied that melt 'way down at 119 degrees, Fahrenheit These alloys are still experimental, still relatively expensive, and still without important application, but they do demonstrate that the search for new materials has not been forgotten in the effort to find new wartime uses and post-war business for bismuth and its alloys

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LOST-WAX PATENTS

Licensed to Production Pool

SINCE publication of the article on the "lost-wax" process in the December issue of Scientific American the editors have been advised that many of the operations and parts described in that article are covered by patents issued or pending to T. G Jungersen of Summit, New Jersey, who had licensed members of the Jewelrycraft War Production Pool to use his processes where required

CORROSION RESISTANCE

Increased by New Phosphate Coatings

PHOSPHORIC acid solution treatments of steel and zinc surfaces have been used for centuries to increase paint adhesion, and thus to improve corrosion resistance. The phosphating of steel has come into extensive use in the last few years with widespread applications of such processes as Parkerizing, Bonderizing, Coslettizing. and so on.

As a rule, the corrosion resistance of the base metal was never increased appreciably by the phosphate coating alone, the purpose of the latter being chiefly to increase the adhesion of a finish-coat of lacquer, oil, wax, or paint. With the recent development of a so-called "titanium predip" method, however, it is now possible to obtain decided corrosion resistance of zinc-plated steel without a supplementary organic coating. In addition, when an organic coating is applied over the new phosphate treatment, the corrosion resistance is considerably better than that obtained by straight phosphating.

For many years it has been known that mechanical wiping of the surface of zinc-plated steel just prior to phosphating refined the structure of the subsequent phosphate coating and increased the corrosion resistance of the finished article.

The new process, developed by Mr. George Jernstedt of Westinghouse's Meter Division, replaces the mechanical wiping with an immersion of the zinc-plated steel in a "titanium-activated" disodium phosphate solution. Titanium activation is achieved by adding a soluble titanium salt to the disodium phosphate at the time the bath is made up, so that the titanium is present during the evaporation-to-dryness operation which is part of the preparation of the bath

The titanium disodium phosphate predip remains active for weeks at a time, and its relative cost is extremely minor. The finish obtained on steel or zinc is unusually smooth and fine-grained, and lacquer may be applied without any rub-down of the surface Finally, the coating is so smooth and corrosion-resistant that in many cases a subsequent organic coating may be dispensed with

MILITARY CONSERVATION

Shows What Can be Done When Necessity Demands

SOME of the over-all conservation achievements of American industry and of the armed forces were described by Howard Coonley, chairman of The Conservation Division of the War Production Board at the joint Toronto meeting of the American Society of Mechanical Engineers and the Engineering Institute of Canada

The steel cartridge case program still stands out among ordnance savings After many obstacles were overcome in the fabrication of a satisfactory steel case, the 45-caliber ammunition was completely converted from brass to steel, with production now running many millions per month The 30- and 50-caliber sizes are also in production at a somewhat lower rate In addition, the 10 5mm, 20mm, and 40mm cases and even the Navy's 3-inch cases have been certified for combat use and are now in full production At the present rate, brass in excess of 200,000 tons a year will be saved by the continuance of this program

In the use of die castings as a conservation measure hundreds of items have been changed from screw machine products, forgings, sand castings, and so on Die castings give high-speed production and involve very low scrap loss, and their employment has provided high savings in materials, manpower, and machine time

Many government specifications have been changed in the interests of conservation. For example, specifications for bronze valves were changed to cast iron, sometimes with bronze seats. Cast aluminum searchlights became sheet steel, and bronze wire screens were converted to galvanized steel. Fire-hose couplings were changed from high-tin bronze to malleable iron for shore use and low-grade bronze for shipboard Many other conservation means have been described in recent issues of this magazine.

Simplification and standardization have also been helpful. For example, a new fluorescent lamp schedule that reduced types from 3500 to 1700, colors from 13 to 3 and voltages from 32 to 7 actually saved 35,000 pounds of solder and 2000 pounds of tungsten and released 1.2 million man-hours per year.

Winning The Battle With Snow

Modern Methods of Snow Removal and Disposal, as Practiced on Airports, City Streets, Highways, and Railroads Are Equally Applicable to Parking Lots and Long Driveways of Industrial Plants. No One Scheme of Attack Will Do a Big Job. Mechanical, Chemical, Heating Methods Outlined

By HAL W. HUNT
Editorial Staff, *Engineering News-Record*

Snow removal is one of the major battles of the home front this year The strategy of the attack, which must be mapped out months in advance, involves the use of an army of men and the use of mechanized equipment, some of it only recently perfected No one group of workers or scheme of attack is sufficient. All must work together in a well planned advance to prevent being overwhelmed by the forces of winter.

As the first illustration of modern snow fighting, consider what goes on at a big airport. Weather reports, available far in advance of those furnished to civilians, warn of an approaching snowstorm, usually with some information as to its probable duration although its intensity is difficult to predict The airport maintenance engineer plans the strategy of battle, selects the crews to make the initial attack, and sees that all machines are given thorough servicing in preparation for the grueling hours ahead

Clearing starts when the snow is about two inches deep The best method of attack is small machines in front, followed by heavier and slower units, the latter perhaps supplemented by minor auxiliary machines The attack leaders are one-way plows, pushed by medium-size trucks at 25 to 35 miles per hour, which throw the snow to one side. When snow piles up to a point where the speed is reduced so that the plows are merely pushing the snow rather than throwing it off the blades, larger plows, probably with adjustable side-mounted wings, and heavier truck units are indicated

Next in the procession of machines on a well equipped field is a one-way plow delivering snow to a wing in which is mounted a rotating vane driven by a separate motor located on the truck behind the cab This vane boosts the snow, already moving in the same direction, off the end of the wing and 40 to 50 feet off the runway. If heavy windrows build up, it is sometimes necessary to bring in heavy rotary snow throwers that break down hard banks of snow and throw it 50 to 100 feet.

The foregoing sounds simple enough but when the operation is performed at night in a driving storm, with planes expected to land at any time, and when runway lights along the field are obscured by falling snow, it takes on all of the aspects of real fighting.

But getting snow off the runway is only part of winter maintenance on an airport. There are miles of taxiway and acres of aprons from which the snow must be removed so that it will not impede movement of the planes.

Here the snow must be handled differently The relatively narrow taxiways to be traversed by planes only at slow speed can be cleared by a few passes of the plows, but the aprons are another matter. The wide paved area, often with only small open spaces between taxiways or runways, offers little room for disposal of snow The procedure here is to plow as much of the snow outward as is possible, allowing it to accumulate along the exterior edge, then plowing additional swaths out and piling it against the banked snow

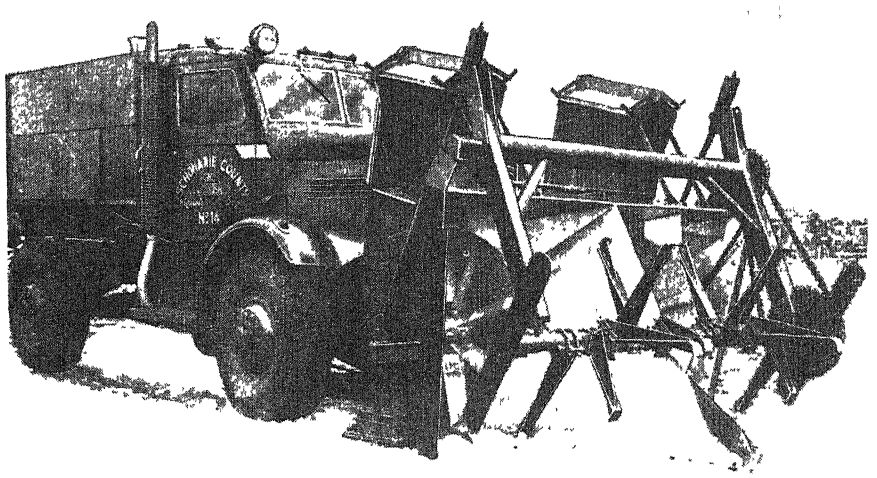
Near the buildings, however, there is no alternative but to load the snow and haul it away. The rotary plows, used for breaking up and dissipating windrows, generally are equipped with hoods that can be used for deflecting the snow into trucks Thus these rotary units continue to be used after the runways themselves have been opened for traffic The conveyor type loader can be used here if available This machine is a self-powered outfit on crawler treads or wheels, that can work itself along a windrow, having paddles or some other device for breaking up packed snow and ice and feeding it to an endless conveyor belt that carries the snow to a point high enough for discharge into a truck.

Beyond the paved limits of the runway, it is desirable to slope the snow to an easy rise to prevent drifting on the runways and to assist in preventing damage to a plane in case it skids and veers off the paved area. Also important is rolling the snow on the rest of the field to compact it to prevent blowing and to give a reasonably smooth surface.

An ever-present hazard is ice or solidly packed snow that may not be removed by the original plowing. Blades mounted under the body of a heavy truck sometimes are useful in removing such ice but the best solution appears to be to spread abrasive material—sand or cinders, for example—over the ice and leave it until action of the sun melts it But the sand or cinders will not stay on the ice under action of high wind or propeller blasts. Consequently, the abrasive materials have to be heated so that they will embed themselves in the ice, or treated with low-melting-point chemicals that will soften the snow sufficiently for the material to gain a foothold

Big trucks with hopper-bottoms and a screw conveyor feeding to the rear

Rotary snow throwers dissipate snow piled up by plows



The rotating forks at the front end of this machine break down any kind of snow bank and feed it to blowers which throw it well off to one side

are used for this work, with actual distribution on the field by rotating spreader. Here again the forces of winter are difficult to overcome, since the abrasive materials freeze in stockpiles and require heating and drying. Then there is the continuing problem of applying the materials while hot. Reaching successful stages are experiments on heating the material in the truck with oil burners so that it falls almost white hot on the ice, thus winning a toehold that can be readily maintained.

The application of heated abrasives is quite expensive and can be avoided by use of calcium chloride or other chloride treatment of the sand or cinders. The objection to the use of chlorides is that they may cause an accelerated oxidation and rusting of metal parts, particularly the intricate mechanisms of the wheel-retracting devices on airplanes. This scheme is quite widely used, however, despite the objection, in which case the chloride splashings are carefully washed off the plane as soon as practicable.

Similar operations are used on city streets, employing similar machines but essentially different methods. When the news of an impending storm arrives, the snow-plow units, held in reserve, are put on the garbage collection and other heavy trucks owned by the city. Owners of suitable trucking units, contracted with far in advance, are notified to stand by to assist in disposing of snow. In the larger cities the snow-fighting equipment is distributed throughout the area in accordance with an organization chart made up during the summer months; supervisors of the various city departments are assigned with their personnel to specific work so that when snow starts to fall each can move quickly in a coordinated, all-out attack.

Like the airport clearing, first equipment of the attack is light one-way plows on moderate size trucks. Here, however, the plows are designed so that snow slides across the blade rather than being thrown. One or two passes with the plows ordinarily pushes the snow to the gutter where it is left to melt naturally if the snow is not expected to be of long duration or is loaded on trucks and disposed of off the streets. Crosswalk clearing is an important factor in street work and here small wheeled tractors with bulldozers are especially helpful.

Experiments have been made on machines to dispose of snow by melting it on the street or runway but to date have not proved entirely satisfactory. Most machines burn oil and direct a flame downward against the paving. Some difficulty has beeen experienced in getting all of the burners to function properly, and to continue operation. If a stop is made to adjust one of the burners while the rest continue to function, the pavement surface is likely to suffer some damage, so to date "frying-pans" have not been widely accepted

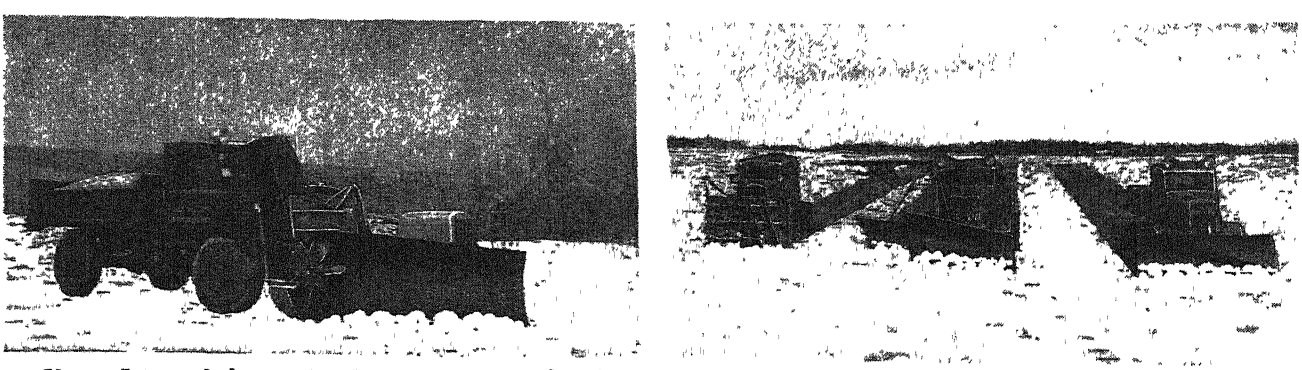
Other machines frequently are pressed into emergency service for moving snow Large, lightweight buckets are used on power cranes and shovels, making these units efficient snow loaders. Tractors with bulldozer and angledozer blades and with regular snow plows are useful in heavy snow, while patrol blades, with or without snow plows and wings, find many applications Tractors mounting high-lift scoops and overhead shovels also serve as auxiliary equipment

Final diposal of the snow is a major problem. In seaports, such as New York, much of the snow is disposed of by driving the trucks out on docks or wharves and dumping it overboard into the salt water. Movement of the tides and the low freezing point of the salt water prevent any building up of dumped snow even where a considerable amount may be disposed of at one point. Dumping into small fresh-water courses, where the water may already be near the freezing point, might restrict the flow of the stream and cause difficulties. Dumping on vacant land is often possible and a large amount of snow may be disposed of into sewers through existing manholes, a stream of water from a hydrant being used to flush it down and assist in melting

Snow, slush, and ice can be effectively removed from the pavement by applying a stream of water under pressure to loosen the material and flush it to the drainage inlets This method, limited to times when the temperature is above freezing and where water is available, is reasonably successful since little equipment is required, paved surfaces are swept clean, and parked cars do not seriously interfere with the operation

Highway maintenance crews perhaps have the best general organization throughout the year for adaptation to snow handling and the greatest flexibility of forces for what they must do They also have an advantage in clearing only a moderate width and generally just throwing the snow off the highway and leaving it But they do have the enemy of drifts that occur less frequently on airports or in the cities Highway cuts, through hill country, often fill with snow and offer serious obstacles to removal because of high banks on the sides.

Machines for moving snow on the



Above: A type of plow equipped with a rotary impeller that cuts an eight-foot swath, throwing the snow aside in a single pass over an airport runway. In the illustration at the right is shown an effective working force for use where large areas must be kept completely snow-free. At the right in the photograph is a one-way plow. Center is a one-way plow with a side wing. The third machine, at left in the illustration, is a rotary snow thrower provided with helical screws for breaking down banks

highways are similar to those for airport runway clearance—light one-way plows operated at high speeds, heavier plows with wings on four-wheel drive trucks, the blade plows with powered rotary vanes, and finally, the big rotary snow throwers for moving packed snow.

Abrasives to avoid skidding again are necessary but here there is less tendency for the material to blow off the road and less objection to the corrosive effect of chloride. Ordinarily, abrasive materials are treated with calcium chlorides as they are stored and then additional chloride added as they are prepared for actual placing on the road. In some cases common rock salt is spread over the highways, particularly at intersections, to prevent the snow from packing and becoming hard When the rock salt is applied early it is possible to plow the highways or city streets clear at almost any time as the snow has a tendency to "mush-up" rather than compacting.

The railroads have their own battle against snow. In most of the areas of the United States, except the mountains, their problem is as much one of keeping switches and yards open and free of snow as it is of getting any considerable quantity of snow off the main line Snow removal on single-track lines is done generally by V-plows on a work train heavily loaded to give it weight, on double tracks one-way plows are used, both types being operated at relatively high speed to throw the snow. Yards are cleaned with what is known as a Jordan spreader that has plows and bulldozer wing-blades at the side that push the snow laterally. Much loading of snow is necessary in restricted areas of platforms and yards. Clearing and freeing of switches is done quite generally by various types of heaters, including steam and oil and gas burning devices and a newly developed electric unit.

Because of the dependable army of home front workers, planes take off headed into a snow storm with no misgivings about others having a place ready for them to land Motorists and trains are so infrequently stalled by snow that it is front page news if they are. And the so-called stay-at-home may drive his car from his home to his office before he has time to shovel his own front walk Men and machines, under the guidance of the engineer, generally can win the battle with snow before it really gets a foothold, but snow is a formidable foe with an unlimited reserve, and is not to be treated lightly.

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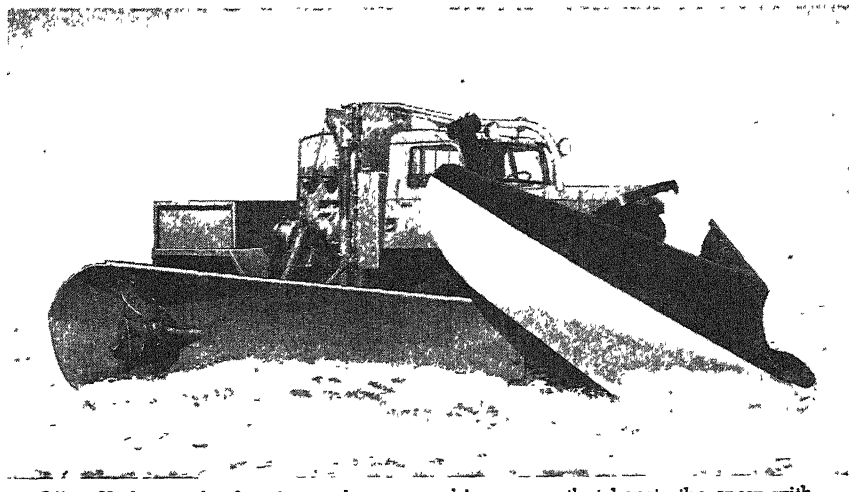
SLUDGE CAMOUFLAGE

Conceals Light Colored, Exposed Soil at Plant Site

DRIED, digested sewage sludge, the solid residue from municipal treatment plants, has been found useful as a camouflage material at one of our new war production plants. Because of its strategic location, it was decided to provide protective concealment measures for the plant, but one of the major problems was to obliterate reflection from the light-colored soil on the plant site, which was exposed during construction operations.

Tests revealed that dried sludge—available in large quantities from a nearby sewage treatment plant—was ideal for a ground cover. The material is dark brown in color, has the physical characteristics and appearance of humus, and is free of any odor.

Some 30,000 tons of sludge were hauled to the plant and spread to a depth of several inches. Not only did this provide a cheap and effective means for immediate obliteration of ground reflection, but the sludge is expected to serve as a soil conditioner to promote the growth of grass.



Offset V-plow and side wing with a power-driven vane that boosts the snow without changing its direction is fastest of the big snow plows recently designed

HORIZONTAL WATER WELLS

Now Being Successfully Used by War Industries

A NOVELTY when it was introduced to this country a few years ago, the horizontal well has now achieved considerable importance as a means of obtaining the large quantities of ground water required by industrial plants engaged in war production. Technically described as a radial well water collector, a single unit will produce as much as 10,000,000 gallons of water daily, and some plants employ as many as seven units to meet their needs.

A radial well consists essentially of a large shaft (about 16 feet in diameter) sunk to a depth where groundwater prevails, and from this shaft are driven horizontal, perforated pipes for distances up to 300 feet. Radiating from the shaft, like spokes from the hub of a wheel, each collector pipe conducts water to the shaft from which it can be lifted to the surface. The perforated screen pipes are eight inches in diameter and the number of pipes projected is determined on the basis of the amount of water desired and the specific geological conditions encountered

The success of this method of abstracting water from the ground rests in large measure on the development of a suitable boring head by which projection of the collector pipes is facilitated In Europe, radial wells have been built by simply forcing horizontal strainer pipes of small diameter into the ground, but this procedure results in compressing the ground around and ahead of the pipe so that permeability of the adjacent soil is greatly reduced, with resulting loss in water yield.

This problem was tackled by Leo Ranney, a petroleum engineer of California, who perfected and patented a boring head of special design. With this head attached to the outer end of a screen pipe, it is possible to remove fine sand and silt that are in the path of and around the pipe as it is projected outward. In effect this permits the formation of a subterranean gravel pack around the screen pipe, the permeability of which provides easy access of water from the surrounding ground into the perforated pipe.

The screen pipes are projected through port holes near the bottom of the concrete well casing by means of hydraulic jacks. As the pipe is jacked out into the ground, additional lengths are welded on. The jacks rest against the wall opposite the port holes through which the pipe is being extended.

CONCRETE SCALING

Minimized With Linseed Oil Emulsion

SPRAYING of newly laid concrete paving with an emulsion of linseed oil has practically eliminated surface scaling, according to engineers of the Ohio state highway department.

This cheap and effective procedure to minimize surface disintegration and maintain a smooth pavement costs only 2½ cents a square yard. To apply the linseed oil, water and kerosene are added in the proportions of one part oil to an equal volume of kerosene and eight parts of water; in addition, ¼ pound of soap powder is included for every gallon of linseed oil.

The resulting emulsion is applied with a standard highway pressure distributor at the rate of 0.1 gallon per square yard of pavement.

What Glass Is and Isn't

If You Can Define Plain Common Glass You Are Wiser Than Average. Has the Essence of it Something to Do with Transparency, Brittleness, Artificiality, Ceramics, Chemical Composition? Try to Define Glass Before Reading; but None of these Goes to the Root of it. You Can Start an Argument

By C. J. PHILLIPS
Corning Glass Works
Author of "Glass The Miracle Maker"

THERE IS a substance, so common that we usually take it for granted, but so uncommon in many of its characteristics that scientists have had trouble finding a name that exactly suits it. At the end of many years they still are not completely satisfied with their choices. In their less abstruse moments, they call this substance "glass" At other times they speak of it as a solid, an amorphous solid, a liquid, an undercooled liquid, and so on.

This would not be a matter of much significance were it not that glass is a material well worthy of study, not only for reasons which are obvious but also for several which are not. Usually we consider glass important because of its optical, chemical, or electrical properties. We think at once of windows and lenses for military fire control; of fruit jars and drinking glasses; of tubes in the home radio and antenna insulators hitched to the tree in the back yard Yet, as Dr. Frank Preston points out, ". . . . the largest single piece of glass ever made, and by far the most valuable, viz., the 200-inch mirror for Mount Palomar, is made of glass, not for any optical property, not for transparency, not for electrical resistivity, but for its mechanical properties. In this case we are concerned with permanence of shape, freedom from 'creep,' freedom from elastic hysteresis, freedom from warping and from thermal distortion. For in that mirror, the silver or aluminum is on the front face, not the back one, and the light never passes through the glass. The glass is a purely mechanical support for the almost infinitesimally thin mirror. We use glass in this case, not because it is transparent, but because its general rigidity and permanence of shape are better than steel or concrete."

This observation, which may be old stuff to some, is new stuff to most. It is not generally appreciated that in such respects glass is the ideal solid and that as such it is perhaps the best material we have in which to study the mechanical properties of matter. Moreover, this study can extend over a range of many hundreds of degrees Centigrade as the material changes continuously from a true (though perhaps unusual) liquid at high temperature to its common form at room temperature. Only for these and similar reasons has it seemed desirable to add another article to the already voluminous list concerned with "What Is Glass?" And even these reasons are not valid unless the present article can in some measure clarify the situation by reducing it to its simplest terms.

We shall have to start with something very simple indeed, setting aside our specific subject for quite a time in order to fill in scientific background preparatory to the return to glass.

Almost every substance can exist in three states· solid, liquid, and gaseous. The elementary physics texts distinguish them by the descriptions and examples given in the accompanying tabulation.

THE THREE STATES OF MATTER

State	Description	Examples
Solid	A solid has a definite shape and a definite volume, and offers resistance to any attempt to change these.	Wood, granite, coal, iron, gold.
Liquid	A liquid has a definite volume but no definite shape. The shape of a liquid is the same as that of the containing vessel.	Water, alcohol, kerosene, turpentine.
Gas	A gas has neither a definite shape nor a definite volume. Both are determined by the containing vessel.	Hydrogen, oxygen, chlorine, carbon dioxide.

The description of each state is so fundamental, so much a part of our everyday thinking, that normally we have no difficulty whatsover in deciding whether a diamond, for example, is liquid or solid.

Now, two very different things can happen to any substance, whether solid, liquid, or gas. It can change chemically· iron rusts, milk sours, gunpowder explodes. It can change physically: steel springs bend, glass springs bend, snow melts, water freezes.

We shall first consider one kind of physical change. In developing this concept it is instructive to consider the ordinary behavior of most of the solid substances with which we are likely to be familiar. If one of these—ice, for example—is heated to its melting point, it changes abruptly to a liquid water When melting of such a solid begins, the temperature remains constant until all the solid becomes liquid Upon cooling, the reverse phase changes take place The liquid changes to a solid when a certain temperature, specific for each substance, is reached. Solidification takes place at the same temperature as for melting and this temperature remains constant until all the liquid is solidified. If the temperature of the cooling liquid is plotted against the time, there is a break in the curve at the freezing point of the liquid. In this process of cooling and solidifying, such substances form solids which have a fixed, regularly repeated, geometric structure. These substances are called crystalline solids. Ice, the metals, and most laboratory chemicals are familiar examples

The elementary parts of crystalline solids may be ions, atoms, or groups of atoms. Common salt, NaCl, is an

ionic crystal The sodium ions alone form a face-centered cubical lattice; likewise the chlorine ions alone. Each positive sodium has six negative chlorine neighbors; each chlorine has six sodium neighbors. X-ray analysis has proved to be a very powerful tool for determining the structures of other crystals, most of them much more complicated than salt. But make note of an interesting viewpoint· If we wish to retain the very useful idea that "a molecule is the smallest particle of matter that possesses the characteristics of the mass." then the whole salt crystal is really a single gigantic molecule! For, we cannot tell *which* sodium is associated with *which* chlorine. The molecule, Na^+Cl^-, has lost its identity. We can say only that a great number of sodium and chlorine ions are joined together, in a certain distinctive way, by chemical or physical forces. As a matter of fact, there may be several distinctive arrangements, each involving the same atoms. We have monoclinic sulfur and rhombic sulfur, gray tin and white tin. There are six known crystalline forms of ice, but we call them all "ice."

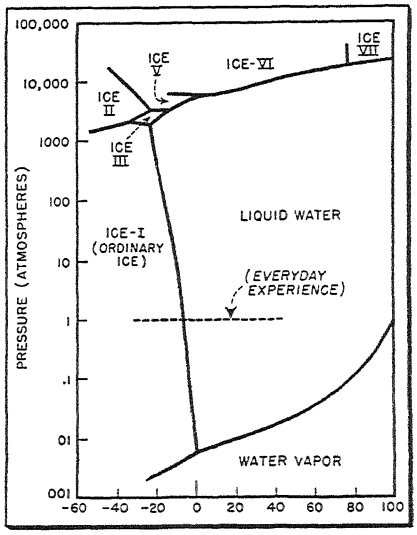
We may, with equal propriety, argue that a liquid, like a crystal, should be considered a single molecule: a "molecule" which can flow, because the constituent parts can change their linkages, but which in any case always retains a certain limited regularity of structure The regularity or orderliness is less than for crystals, but it is there. and can be shown by X-rays.

It is becoming increasingly obvious that solids and liquids have much more in common than was originally supposed In elementary mechanics, we like to think of solids as rigid, retaining their shape perfectly, and of liquids as incompressible, retaining their bulk perfectly, no matter what forces act upon them. Actually we know that such substances do not exist. Even the best-behaved solids, if acted upon in one direction by great forces, exhibit an elastic limit Beyond it, they retain a deformation or "set," whose extent and permanence depend upon the duration of the excessive stress. The solid has begun to show the plasticity of a very viscous liquid. In this sense, ductility and malleability are both quasi-liquid in character. There is a large, vaguely classified group of materials, called amorphous solids, which no one can quite force himself to call either liquids or crystalline solids. Pitch, tar, wax, lard, gutta percha are in this category.

In this way, example can be piled upon example to show that no solid, and no liquid, is as "perfect" as we would like it to be for mental ease in definition. We cannot lock each concept in its own air-tight compartment. In many borderline cases it is difficult or impossible, and probably futile, to distinguish one from the other.

Now, when we come upon a substance which is fabricated at very high temperatures, which in fact can be fabricated only because it is then a very viscous liquid, but which it always used at lower temperatures as a hard, rigid solid—then we can confidently expect difficulties in definition Such a substance is glass.

At room temperature a glass is obviously a hard, rigid solid, in the ordinary, rather loose meaning of those terms, and it apparently remains a solid as its temperature is increased several hundred degrees Centigrade. As the temperature is still further increased, it gradually softens, almost imperceptibly at first, and finally becomes a viscous liquid, without exhibiting any sharp melting point



In everyday experience water has three states, or phases—the solid (ice), the liquid, and gaseous (water vapor). Within recent years several more icy states have been discovered when water was put under extremely high pressures. Ices II and III melt at lower temperatures than the familiar Ice I but Ice VII doesn't even freeze until the temperature has been raised to 179 degrees, Fahrenheit; and if the pressure is raised still higher its freezing point will be higher than the boiling point of water at atmospheric pressure. Therefore "hot ice" isn't just a case of hot air. These different states of ice result from changes in crystal structure due to the high pressures and temperatures involved

At high temperatures glasses are ordinary liquids which, like all liquids, assume the shape of the container and flow under the action of any small force. When this liquid is cooled it does not devitrify; that is, it does not undergo a discontinuous change into a stable crystal or aggregate of crystals. At the temperatures at which glasses might be expected to crystallize they are still liquids, liquids of such great viscosity that they can be cooled through their freezing points without devitrification. They thus become "undercooled liquids." The increase in viscosity is a continuous process from the very hot liquid to the rigid glass at ordinary temperatures. Glasses have smooth cooling curves without the sharp break which indicates the freezing point of a liquid which crystallizes as it cools. Morey summarizes this behavior and defines a glass as follows: "A glass is an inorganic substance in a condition which is continuous with, and analogous to, the liquid state of that substance, but which, as the result of having been cooled from a fused condition, has attained so high a degree of viscosity as to be for all practical purposes rigid." This kind of material is a glass, regardless of its chemical composition.

It is possible to argue almost endlessly about some of the expressions used in the last paragraph. There have been violent objections to the term "undercooled liquid." It is pointed out that glass at room temperature is much less capable of flowing under stress than such characteristic solids as iron and steel. If various estimates are correct, strain-free glass formed at the dawn of creation and subjected ever since, at room temperature, to as high a stress as it would stand, would not have flowed at all within the limits of observation This is probably true and from that point of view, but that point of view only—in the cold, one might say—the term "undercooled liquid," used in any popular sense, probably strains one's credibility. But glass would not be glass, at room temperature or any other temperature, were there not a strong but highly flexible system of atomic bonding carried down continuously, and reversibly, from the high temperature condition. It is therefore vital to retain this concept, and this the expression "undercooled liquid" does do

The term "amorphous solid," also applied to glass by scientists, is both useful and misleading. The word "amorphous" is variously defined as meaning formless, irregularly shaped, uncrystallized, or unorganized. Several of these terms give the wrong implications and this classification is too broad and general. The expression is useful if we agree that there is one distinctive branch of the group of amorphous solids—that branch produced by undercooling a melt and giving substances which, at ordinary temperatures, exhibit brittle, conchoidal fractures— and that we shall call such substances glassy or vitreous.

Commercial glasses are not the only representatives of the vitreous state, as it is sometimes called. Certain elements and compounds can be obtained in this condition—selenium, arsenic trioxide, and boric oxide, for example. Pure silica can be fused, without fluxes, and becomes vitreous silica. Stick candy is a vitreous substance. The vitreous state is well represented in nature. In Yellowstone Park there is a great mass of volcanic glass, nine miles long and five miles wide, in which there are only occasional traces of crystalline forms. On the island of Lipari in the Mediterranean there are two mountains of pure white glass better known to us under the name pumice. This useful material is really a glass foam created by trapping countless gas bubbles as the molten mixture solidifies.

If we define ceramic products as being the result of the action of fire on earthy materials, we can see why such apparently different products as brick, terra cotta, chinaware, refractories, enamels, glazes, and glass have much in common. All are certainly created

(*Please turn to page* 39)

Compressed Air In Industry

Air is Used in Almost Limitless Volumes in a Seemingly Unlimited Variety of Work. When these Applications Are Rounded Up into a Synthesis They Constitute an Impressive Array. Many of the War-Time Operations Accomplished Through the Use of Air have Definite Implications for Peace

By ED C. POWERS

AIR, PROVERBIALLY free, has become a vast and limitless resource for America's war production. It is being blown and pumped in great tornadoes to speed planes, guns, ships, food, chemicals, and other necessary war materials from the mines, mills, and factories of the United States to the armed forces around the world.

In such great demand is the force that can be stored up and released in air and other gases, that millions of horsepower in compressors, blowers, and fans have been put to work on a scale gigantic in scope. The Compressed Air Institute, which keeps its fingers on the air arteries of the nation, estimates that distinct and definite uses of compressed air in industry number between 450 and 500.

Blast furnaces and steel mills, metal and coal mines, shipbuilding yards, ordnance factories, and the aviation industry require vast quantities of air and gas that stagger the imagination.

Air is not usually thought of as having great weight because it ordinarily offers such slight resistance to our movements, but industry has come to make its compressed-air weight calculations in millions of tons. For example, the mass of air and gases set in motion by compressors and blowers in the iron and steel industry alone during 1942 totaled about 240,000,000 tons, or about three times the estimated weight of steel coming out of the same mills.

In the shipbuilding and aviation industries, vast amounts of compressed air are used all along the production line, from the point where the castings for the engines are first formed to the final spraying of paint on the finished jobs.

In the ordnance industry, compressed air has made possible rapid forming of huge shells and bombs, and high-speed casting and machining of guns and other weapons.

In the explosives industry, compressed air and other gases are being used to synthesize nitric acid and ammonia—two of the warring nations' most vital chemicals. (See page 270, December 1943 Scientific American, for details of this process. *Editor.*)

Oil refineries are using hundreds of thousands of horsepower for the movement and compression of gases, and in the manufacture of synthetic rubber the demands for compressors to transport air and gas are placing a heavy load upon compressor manufacturers.

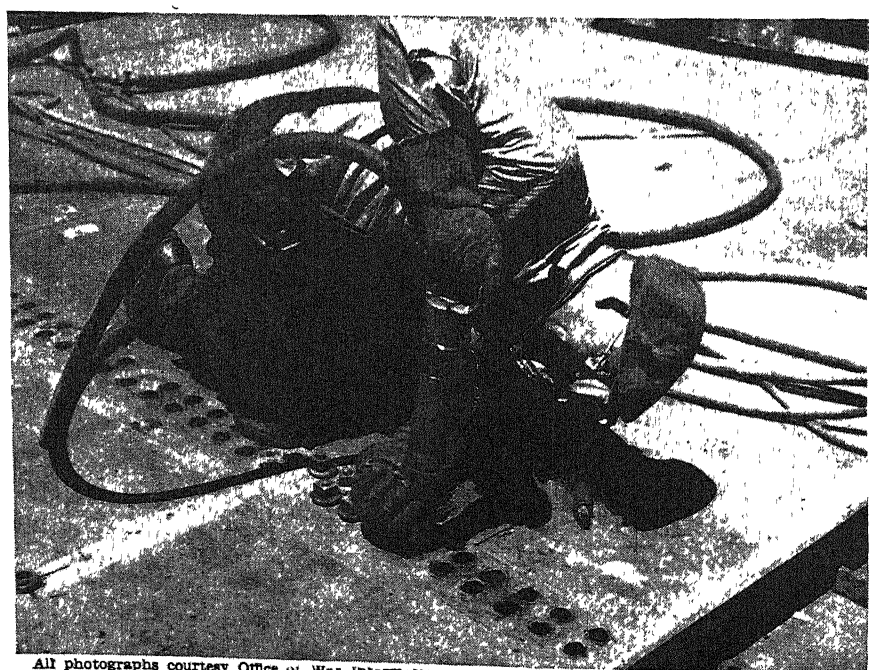
There are compressors on cargo vessels and fighting ships, for the operation of controls, elevators and hoists, and many other appliances. There are compressors for the release of torpedoes, compressors impelling air to blow gases out of guns, and compressors for general ship services.

To provide warmth and fuel for the public and industry, the gas industry runs compressors by the hundreds of thousands of horsepower. One natural gas company alone has 100,000 horsepower in compressors. They use compressors to pump the gas through miles of pipelines and store it away. During the summer months one company, whose compressors total 36,000 horsepower, pumps billions of cubic feet of gas into storage. The largest part of this goes into two large underground reservoirs, and the company is planning to store over 300,000,000 cubic feet by liquifying it and pumping the liquid into huge cork-lined containers In the winter when demands for the gas are heaviest, it is released from these storage reservoirs.

Some of the largest volumes of air are handled in war plants and government buildings for heating and ventilating. As an example, one plant of 5,000,000 cubic-feet capacity moves 1,000,000 cubic feet of air a minute through the plant. At five pounds pressure and 70 degrees, this much air, if perfectly dry, would weigh 500 tons. In other words, just one war plant of moderate size moves 1,220,000 tons of air every 24 hours.

To speed up war production, many industrial plants have installed pneumatic conveyors which send messages and blueprints from one end to the other of a 1000-foot factory in less than 40 seconds. One of the largest pneumatic conveyor systems in the world has been installed in the War Department's Pentagon Building in Washington to speed up communications.

Compressed air is used to control many automatic and semi-automatic industrial processes. At the new synthetic rubber plants valves and other



All photographs courtesy Office of War Information

Air powers this rivet hammer, at work on deck plates of a ship

WARTIME ANNOUNCEMENT!

Revolutionary RADIONICS Product of Great Importance

For All Hard of Hearing – their Friends and Families

$40.00

READY TO WEAR
COMPLETE
—WITH RADIONIC TUBES
—CRYSTAL MICROPHONE
AND BATTERIES
. . . Liberal Guarantee

★

TO PHYSICIANS: A detailed scientific description will be sent upon request. Further technical details will appear in medical journals.

★

There are cases in which deficient hearing is caused by a progressive disease and any hearing aid may do harm by giving a false sense of security. Therefore, we recommend that you consult your otologist or ear doctor to make sure that your hearing deficiency is the type that can be benefited by the use of a hearing aid.

★

The Zenith Hearing Aid can be supplied only by your Zenith franchised Optician or Optometrist (no home calls or solicitations).

Zenith Radio Corporation
CHICAGO

OFFICE OF
E F McDONALD, JR.
PRESIDENT

To: Manpower Authorities, Employers, Physicians,
Parents, Teachers and Hard of Hearing

Our country's manpower crisis calls for everyone's maximum efficiency. Since I lost the hearing of one ear in an accident twenty years ago, I have been acutely conscious of the handicaps of the hard of hearing While pioneering in radio I have for some years directed Zenith's research toward development of the best wearable hearing aid that science could produce.

My own company has spent millions, the radio industry tens of millions for research This research has been paid for by scores of millions of purchasers of radio sets

We, with this technical knowledge and engineering skill, now bring to the hard of hearing a new precision aid — the ZENITH RADIONIC, an instrument of the highest quality

A hearing aid is essentially a part of a radio receiver It wires the human body for sound It is composed of a crystal microphone and parts of a radio receiver set reduced to miniature size and manufactured with watch-like precision For many years it has seemed to me incredible that the public could buy a complete radio receiver for $29 or less with which they could hear the words whispered in Europe, Asia, or South America, but people with deficient hearing have paid $100 to $200 for a comparably good hearing aid to near the human voice across the room

Zenith's facilities and methods for precision mass production of radio sets, Radionic devices, etc., enable it to bring this superb hearing aid within the reach of all

Eye-glasses, like hearing aids today, were once the luxury of the few What the optical companies have done to make the finest spectacles available to everybody at low cost, Zenith is now prepared to do for the hard of hearing — to bring with the aid of modern radionic science a highly perfected hearing aid within the reach of the masses

ZENITH RADIONIC — low cost battery upkeep wearable hearing aid — complete with miniature radio tubes, crystal microphone and batteries — will sell for $40 — about one-quarter of the price of the better vacuum tube instruments of today. Hereafter no one, child or adult, need be without a hearing aid because it is too high-priced There are ten million people, of whom over three million are children in our schools who are hard of hearing

Even if Zenith never makes a dollar at this low price, it is willing to take its pay in the good will of the hard of hearing, their families and their friends. Thus begins a revolution in hearing aids — a revolution to "lower the cost of hearing" within the reach of all

E. F. McDonald Jr.

President,
Zenith Radio Corporation

Write for Free Descriptive Booklet

ADDRESS DEPT. SA-1, HEARING AID DIVISION

ZENITH RADIO CORPORATION ★ CHICAGO 39, ILLINOIS

ZENITH
LONG DISTANCE RADIO
RADIONIC PRODUCTS EXCLUSIVELY—
WORLD'S LEADING MANUFACTURER

Air-driven reamers truing holes in ship construction

controls are operated by thoroughly dried air. Dry air is necessary to insure performance of controls in the lowest sub-zero temperatures.

Compressed air is also used to operate many safety appliances in machine shops.

In shipbuilding, aircraft construction, ordnance, and other industries doing war work, the contribution of compressed air in saving of production time has been most spectacular The foundry molding machine revolutionized the production line in the automobile industry In the early days of the industry completion of three or four engine blocks by hand was a day's work for a molder and his helper. Today a pair of molding machines operated by two men can turn out large automotive engine blocks at a rate of one a minute. These machines are operated by compressed air, which jolts, rams, and squeezes the molding sand, not only many times more quickly than hand labor can possibly do it, but also more uniformly and more precisely.

The aircraft and shipbuilding industries use immense volumes of compressed air to operate hand air drills, grinders, riveters, impact wrenches, vises, automatic chucks, and expanding arbors. Modern pneumatic tools are light and compact, and they pack a lot of power for their weight and volume Highly flexible, they can be used for long hours without fatiguing the worker Portable compressed air hammers are designed to drive rivets from the very tiniest to giants 1½ inches in diameter. Pneumatic hammers can deliver as many as 10,000 blows a minute.

In these and related industries, air pressure is necessary in die forming and molding operations for the ejection of metal parts from the dies. Compressed air is used to obtain and control the proper pressures between electrodes in welding machines. Compressors make a large contribution in the storage of oxygen, acetylene, and other gases for welding and many other vital operations.

One of the more recent applications of gases under pressure is in "metallizing" worn machine parts, a process which is also used for adding metal to surfaces to prevent corrosion. The molten metal is sprayed onto the part under treatment, as shown on our cover.

As the potential supply of high-grade iron ore on or near the surface of the ground in the United States diminishes, more and more underground mines open up On the surface the iron ore is scooped by steam shovels, but when it comes from underground, the ore bodies must be drilled and blasted. This requires compressed air for drilling on a large scale.

Just as compressed air must accompany men underground for the recovery of valuable ores, so it also must accompany men under the water for the recovery of sunken ships Salvaging of ships requires compressed air for diving suits and other appliances to aid in bringing engines, cargoes, and sunken hulks to the surface. Salvage crews of the United Nations are recovering engines, reconditioning them, and giving them new jobs in ocean transportation

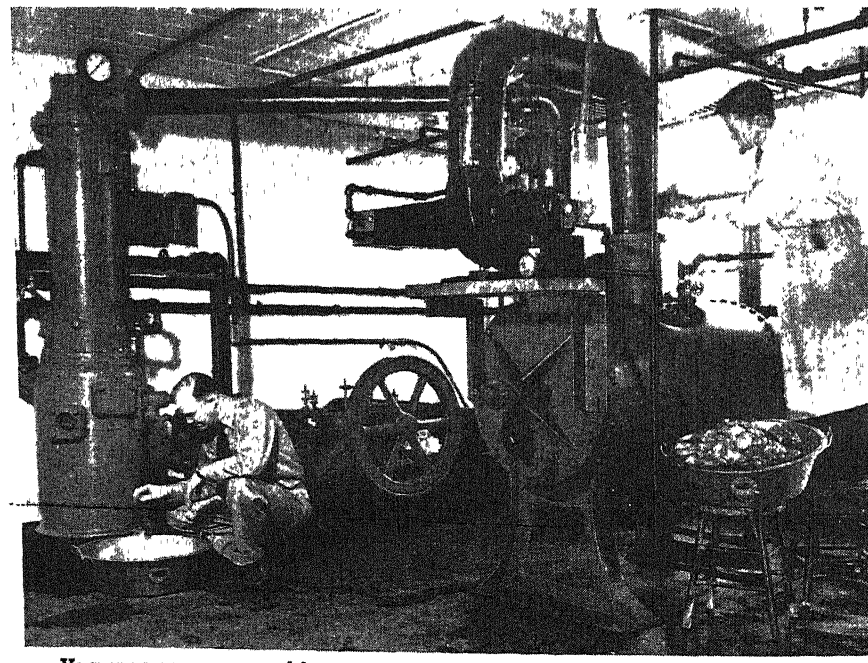
Compressed air hammers are used in breaking rock and tamping concrete Large volumes of cement are transported to construction jobs by means of air that forces the material through pipelines. Air compressors are transformed into vacuum pumps to draw excess water out of poured concrete to speed the work and improve the quality

The huge chemical industry upon which the world depends for synthetics, for basic materials for plastics, for explosives, and for many other valuable products, uses air and gas in many degrees of pressure, from the highest pressure to the greatest vacuum Vacuum pumps make possible the production of some vitamins, valuable for the maintenance of nutrition Distillations are carried on in many degrees of pressure. The industry uses air pressure in filtration and agitation of liquids, in flotation processes, and in numerous other applications.

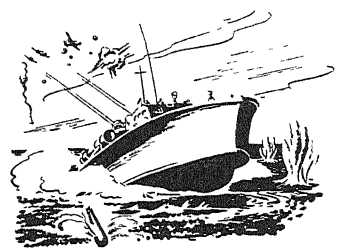
Before the war ends, this country will have sent hundreds of millions of pounds of dehydrated food to our soldiers, sailors, and marines and to people needing relief in many lands Blowers and fans are used to drive the air which removes the water from the food.

The electrical industry is constantly using compressed air and trying out new and often important applications In their research they have developed circuit breakers using compressed air, to protect high potential lines from dangerous shorts. Six-hundred-mile-an-hour wind gusts are being applied in 22 circuit breakers to protect the electrical equipment at a large new steel mill in the West.

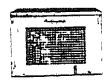
The nation's railroads probably have the highest number of different applications of compressed air of any industry. It is used for starting fires in coal-burning locomotives, as well as in the superchargers of the new oil-burning Diesels. It operates pneumatic hammers and drills, cleans flues, calks boilers and tanks, operates air hoists, lifts, and jacks; operates turntable motors, drills holes for bond wires, places and removes track nuts, operates third-rail ice scrapers, delivers sand and fuel to locomotives, lays new tracks, cleans switches, operates crossing gates as well as switch and signal systems, operates sand blasts for removing paint, cleans castings and so on, operates pneumatic sand rammers, sprays paint and white-



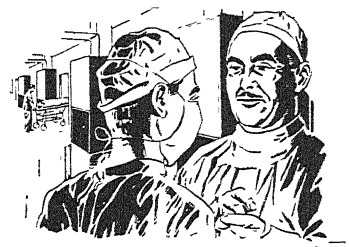
Vacuum pumps are used in some processes of food dehydration, a rapidly growing industry. Shown is an experimental pork-dehydrating set-up, with vacuum pumps



Fresh food on the high seas during long, heavy-action periods away from port is the result of compact, efficient refrigeration

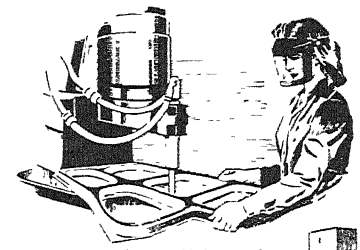


Self-Contained
¼ h.p. Refrigerating Unit



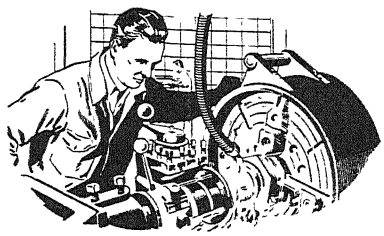
Cool, clean air protects the life of the wounded in Army hospitals Special aircraft refrigerators safeguard serums and plasma.

Aluminum
Aircraft Refrigerator



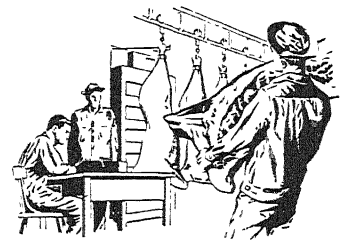
Peak welding efficiency is made possible by cooling of welding tips with water or brine held at the right temperature.

Spot Welder
Tip Cooling Unit



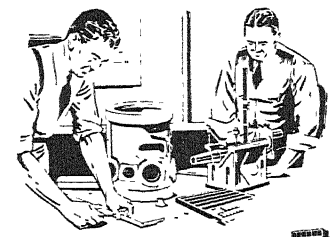
Tool life is increased and rejections are fewer when cutting oils used in high-speed machining are properly cooled.

Refrigerating Unit



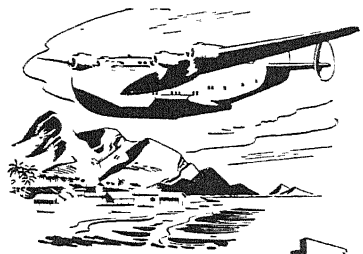
The health of our armed forces is protected by dependable refrigeration in cantonments, huts, barracks, and on ships.

14 Cylinder
Refrigerating Compressor



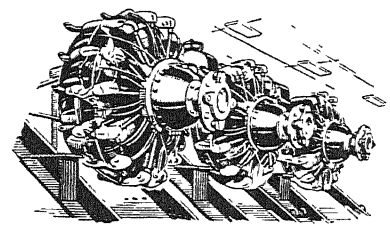
Super accuracy in gauge rooms is possible when the air is clean, dehumidified, and maintained at a constant temperature.

3 h.p. "Packaged"
Air Conditioner

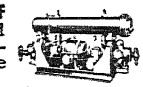


Protection in the tropics against the ravages of humid atmosphere and vermin is necessary to preserve food and equipment.

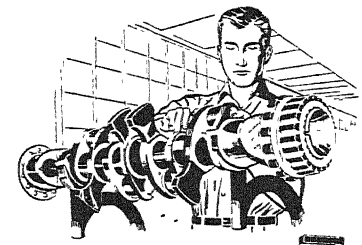
Portable Panel
Refrigeration Unit



Identical performance of aircraft engines is assured by operation tests with carburetor air kept at the same temperature.



14 Cylinder
Air Conditioning Compressor



Clean, dry atmosphere is vital for machining sensitive metal surfaces where a spot of rust would ruin high-precision products.

5 h.p. "Packaged"
Air Conditioner

★ CHRYSLER AIRTEMP AT WAR ★

From tiny, fractional horsepower to big 75 horsepower units, Chrysler Airtemp Radial Compressors are performing a major war job on both the production and battle fronts.

The science of air control is built around the compressor. Chrysler Airtemp's *exclusive* Variable Capacity Radial Compressor provides a new efficiency and accuracy in indoor climate regulation. The radial cylinders cut in or out automatically, one at a time, to meet varying load requirements. This flexibility eliminates the peaks and valleys resulting from abrupt starting and stopping of ordinary compressors . . . holds temperature and humidity at a constant level.

Years spent in building delicate mechanisms, have developed high-precision, versatile skills at Airtemp, now devoted to war production. Backed by Chrysler Corporation research and engineering, when peace comes, these skills will again create heating, cooling and refrigeration units for homes and commercial use that will set new, high standards of efficiency and performance.

The lessons learned during peace in free competitive enterprise—freedom of the individual to produce and compete—today bring strength to a nation at war.

War Products of Chrysler Corporation

Tanks • Tank Engines • Navy Anti-Aircraft Guns • Army Anti-Aircraft Guns • Bomber Fuselage Sections • Bomber Wings • Bomb Racks • Bomb Shackles • Fighter Landing Gears • Aluminum Alloy Forgings • Aluminum Alloy Castings • High-Powered Aircraft Engines • Cycleweld Cement • Wide Variety of Ammunition • Anti-Tank Vehicles • Command Reconnaissance Cars • Troop and Cargo Motor Transports • Ambulances • Weapons Carriers • Gyro-Compasses • Navy Pontoons • Marine Tractors • Harbor Tugs • Marine and Industrial Engines • Smoke Screen Generators • Air Raid Sirens and Fire Fighting Equipment • Powdered Metal Parts • Cantonment Furnaces • Tent Heaters • Refrigeration Compressors • Field Kitchens • and Other Important War Equipment

Tune in Major Bowes every Thursday, C B S, 9 P. M., E. W. T.

Chrysler Corporation

PLYMOUTH • DODGE • DE SOTO • CHRYSLER • AIRTEMP • AMPLEX

BACK THE ATTACK—BUY WAR BONDS

Air-driven grinding wheels speed up the nation's industrial war effort

wash, cleans cars and car furnishings, transfers oil, pumps water, sets valves, screws up flash plates, drives nails and spikes, bores wood, tamps ties, pulls spikes, operates pneumatic saws for trimming car roofs and for other construction, straightens rails, and forms and cuts grease wafers.

In many places where danger from sparks makes electricity or steam impractical as motive power, compressed air is used to operate locomotives and ammunition hoists, as in ammunition depots. In gas plants, such as those where highly explosive acetylene is generated, compressed air is used in hoists and motors. It also operates doors on heat-treating furnaces where the temperature runs high enough to burn up electric motors.

As additional examples of its versatility, compressed air is used for agitating pickles in canneries, building tunnels under rivers; regrooving tires; spraying colors and enamels on porcelain before firing; moistening tobacco in cigar and cigarette factories; pumping milk in dairies; carving wood in furniture factories, molding, pressing, blowing, and etching glass in glass factories, unloading logs in lumber plants; starting and maneuvering motorships; lifting oil and gas in wells; fabricating news print in paper mills, mixing drugs in pharmaceutical manufacturing; stopping fires in gas mains; pumping brine in salt wells; handling scenery in theaters; and bending wood in woodworking plants.

All in all, the free air of nature has been harnessed by man to do a wide variety of jobs, many of which have been fostered by the impetus of war production, yet will remain as industrial time and labor savers in days of peace.

⊕ ⊕ ⊕

SOUND CONDITIONING

Reduces Interference With Efficiency

TWENTY machine operators and their machines, hard at work in a busy war plant, have to produce a good deal of noise, but 20 typists and clerks, working in the adjoining room, don't need to have their concentration interrupted by the unavoidable racket next door.

This has been demonstrated in many factories where sound conditioning, long used in auditoriums, schools, office buildings and other structures, has been installed.

Statistics gathered by The Celotex Corporation show that well-planned use of sound conditioning not only lessens the general uproar of a busy plant but creates islands of quiet in thoroughly sound conditioned rooms where workers, whose job does not require noise, may work without disturbance.

Bell Telephone Laboratories estimate that noise which cuts into an average worker's efficiency by 5 percent will lower an executive's output by 30 percent.

SECTION-BUILT

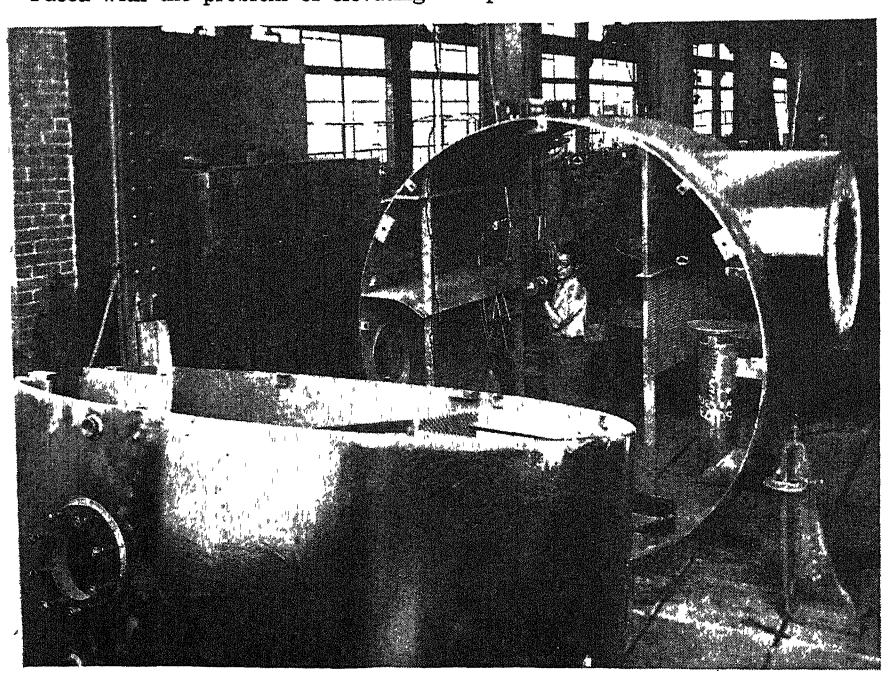
Deaerating Heater Unit Welded on the Job

IT IS seldom that the interior of a deaerating feedwater heater is visible to the purchaser who installs it in his plant. But because of unusual installation problems, the accompanying photograph could be taken, showing the middle section of a 350,000 pound-per-hour horizontal unit, and revealing the bracing, baffles, overflow pipe, and steam inlet connection.

Ordinarily the shell of a feedwater heater is made in one piece. In this case, however, the completed unit was too big for available openings in the existing power plant of a large automobile factory where it was to be installed as part of the expansion necessitated by a conversion to war work.

Faced with the problem of elevating the heater over outside coal bunkers and carrying it in through a steel window frame only 6 feet high and 18 feet wide, Elliott Company designed the unit in three sections for welding together on the job.

The heater was installed in the customer's boiler room at considerable elevation above the pump, where ample room was available for a unit that could be handled sectionally.



The workman is grinding a weld on the center section of a deaerating heater

BIOLOGICAL MINING

Offers Interesting Possibilities for Future Metal Supplies

AS CONCENTRATED minerals are made into manufactured articles and spread over the face of the earth we may wonder how future generations are going to obtain iron, aluminum, and the other elements of which economical production depends on the availability of concentrates. Part of the answer already exists in the commercial success of extraction of magnesium and bromine from that ultimate of dissipation, the sea. The reconcentration of other elements may not be feasible by chemical methods, and biological methods may perhaps be the answer to the problem [Another angle of this "reconcentration" problem is dealt with in the article on page 7 of this issue.—*Editor.*]

Manganese, an important element in high-grade steel, is obtained from large deposits of pyrolusite, which some day will be exhausted. There remain large deposits on ocean floors, the exact origin of which is unknown One hypothesis suggests that these deposits may have been formed by the remains of animal organisms which had manganese instead of iron in their tissues. Even land deposits of pyrolusite may have had their origin in the life cycle of marine animals in prehistoric seas.

The skeletons of many species of diatoms are finely divided pure silica. Oyster shells form an immense reserve of pure calcium carbonate. Some radio-

larians (*Acanthometron*) have shells of strontium carbonate instead of the usual calcium carbonate. The amount of strontium in the ocean has not been determined, yet these animals have power to obtain it in high purity. Vanadium is another element concentrated by an ascidian, and by a holothurian (sea slug) found off the Cornish coast. Iodine, although present in very minute traces in the ocean, is concentrated in certain seaweeds and has been extracted commercially from the ash. Seaweed is used in Ireland as a fertilizer because of its high concentration of potassium, a necessary fertilizer ingredient.

The blue blood of lobsters and king crabs is due to the presence of copper instead of iron, and organic copper salts in marine organisms are of great use in treating pernicious anemia Arsenic, too, is found in several of the ocean crustaceans.

Another well-known example of biological mining is the plant *Astragalus pectinatus,* which takes up selenium from the soil. Selenium has little economic value, and this phenomenon remains merely a scourge on animal raising on selenium-containing soil There is also geochemical interest in the concentration of radioactive mesothorium by a pond plant

Plants which extract gold have been used in prospecting in Colorado to locate veins. Millions may be awaiting the biologist who develops a seaweed which likewise uses gold in its tissues. A sea organism which concentrates tin would be of more intrinsic value today, and is not entirely out of the question because there is a certain species of yellow violet which grows only where it can get tin.—*Industrial Bulletin* of Arthur D Little, Inc.

RADIO HEAT

Proving its Usefulness In Many Ways

Some war production operations have been speeded up by as much as 2500 percent by the use of electronic devices for industrial heating, according to Henderson C. Gillespie of the RCA Victor Division, Radio Corporation of America. Addressing the 587th meeting of the New York Electrical Society, Mr. Gillespie cited the experience of several firms in the aircraft and plastics industries.

One electronic device stepped up the soldering of bases of radio condenser cans from 100 cans an hour to 2500. In addition to soldering, and the pre-heating of wood and plastics for molding, radio-frequency heating has proved its advantages in terms of improved products and savings of time, space, and labor for case-hardening, annealing, and welding of metals, baking paint, tacking plywood, seaming thermoplastic fabrics, drying textiles, and other industrial operations.

By comparison with flames and other usual sources of heat for industrial processes, radio-frequency heating is not only quicker but also permits closer control as to the area to be heated, provides more uniform heating, and for many processes is more efficient and more easily adapted to mass production methods.

The degree of control is illustrated by the fact that one end of a set screw can be brought to a white heat while the other end remains cool. This is an advantage in the manufacture of many machine parts which function best if one portion is case-hardened while adjacent areas remain unhardened

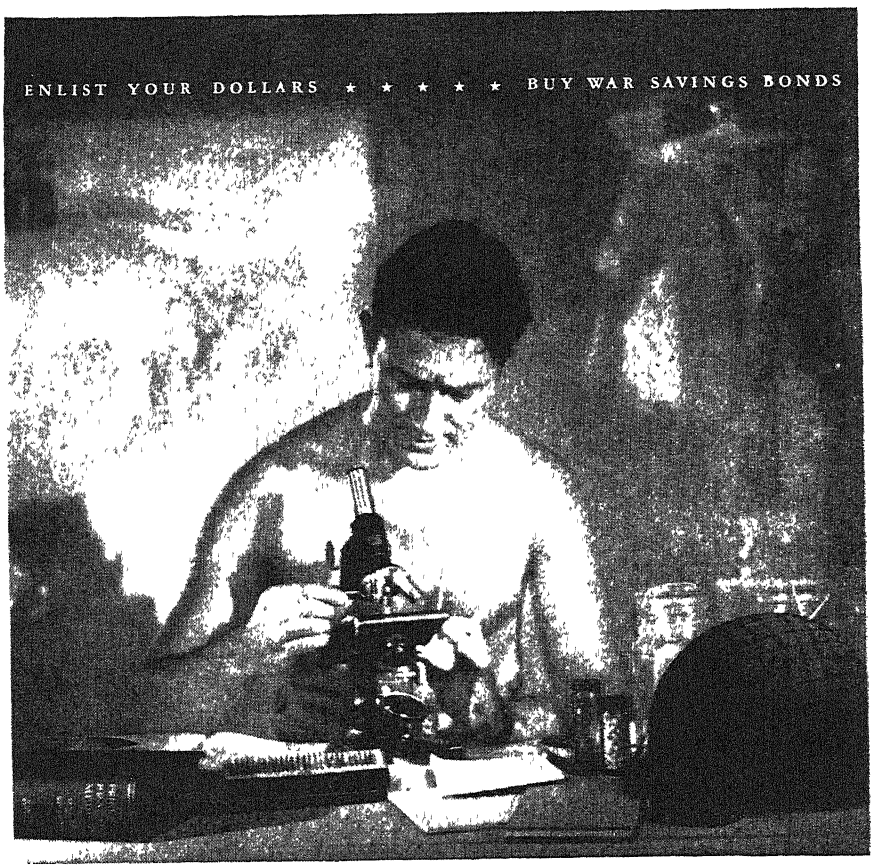
AMPLIDYNE

Puts Electrical Short-Circuits To Useful Work

The short circuit—often blamed for knocking out lights in homes and huge apparatus in power stations—is now increasing the maneuverability of guns on planes and ships and speeding the output of armor plate and other products of war industry.

The short circuit and a coil arrangement known as a compensating field winding are features of a General Electric development, the amplidyne—a simple rotating unit which resembles a motor or generator. The device can pick up small whispers of electric signals and magnify them instantly into powerful commands to large machines

The amplidyne was developed by Dr. E. F. W. Alexanderson and other G-E engineers just before war broke out in Europe. Now, a typical amplidyne assignment is controlling guns in aircraft turrets. Although one man could not, by himself, maneuver guns



How Americans Are Kept in Fighting Trim

On some South Pacific island, in Africa, or on our northern battle fronts . . . wherever there is a force of American soldiers . . . you will find a medical officer equipped with a microscope.

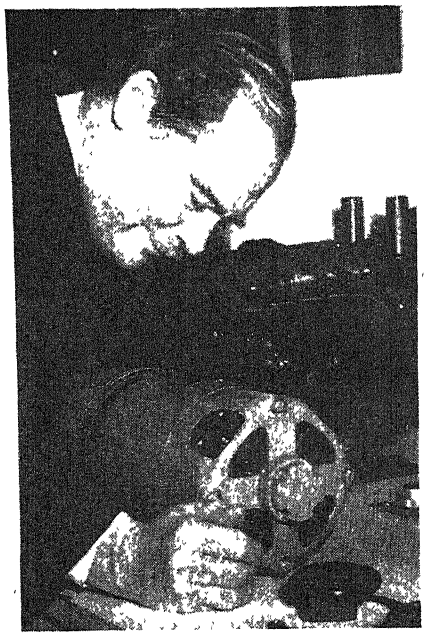
Bausch & Lomb Microscopes follow the flag, over land and sea, to help keep your fighting sons in fighting trim. Medical research . . . and the routine checkups and analyses that must be done in the field . . . are a vital part of military preventive medicine. Through the microscope the Medical Corps knows of the enemies . . . disease and infection . . . that lurk behind every battle line.

Microscopes are typical of the many Bausch & Lomb optical instruments that are performing vital war duty on the home front . . . in the industrial research and control that speed the production of the tools of Victory . . . and in the medical and scientific research that will make it a better world to which these boys will return. Here again, optical science is *seeing it through.*

BAUSCH & LOMB
OPTICAL CO. ROCHESTER, N. Y.

Fight Infantile Paralysis January 14-31

AN AMERICAN SCIENTIFIC INSTITUTION PRODUCING OPTICAL GLASS AND INSTRUMENTS FOR MILITARY USE, EDUCATION, RESEARCH, INDUSTRY AND EYESIGHT CORRECTION



Alexanderson and amplidyne

against the terrific wind resistance encountered by a plane flying 400 miles an hour, with the amplidyne he controls fire power as deadly in the air as a machine gun battery on land, and with the same ease as he would sight a rifle on a target range

Already the amplidyne is in successful operation on fire-control equipment aboard ships, on anti-aircraft guns, and on searchlights both ashore and at sea.

Here are some of the industrial applications of the amplidyne.

Mining: Installed on the world's largest power shovel, the amplidyne is simplifying control and maintenance. On hoists which bring coal from depths of several hundred feet, the amplidyne is also adding to the output of vertical coal mines.

Steel mills: One of the first operations in steel production requires the loading of iron ore and other materials into blast furnaces. The amplidyne enabled one blast furnace skip hoist to produce 49,705 tons of pig iron in a month—a world's record

Hundreds of other applications of amplidynes have been made in the armed forces and throughout industry, all of which can be expected to play equally important roles after the war.

GUN-DIRECTOR

Practically Eliminates Human Errors for Anti-Aircraft

AN OUTSTANDING development in Army ordnance was shown recently when the Army and Bell Telephone Laboratories jointly demonstrated the Electrical Gun-Director. As an Army plane overhead simulated a bombing run, observers noted that four guns of an anti-aircraft battery were following the plane, without manual operation by their gunners, and that they were trained not at the plane but at a point ahead of and above it. Seated at a sizable metal box mounted on a pedestal, observers with eyes glued to telescopes kept the cross-hairs trained on the plane Both telescopes turned vertically, and also, along with the box and the observers, they turned horizontally. By another instrument, the plane's distance was measured After the plane had been "tracked" for a few seconds, the fire-control officer gave the command "Fire!", the shells for each gun were pulled out of their individual fuze-setters, where their burst had been timed under the control of the Director, immediately and automatically rammed home, and the breeches closed The guns were not fired but if they had been the shells would have travelled on a path converging with that of the plane, and would have exploded within lethal range of it Officers who had seen the set-up used against a target said that instead of an occasional hit, the target sleeve was invariably torn to ribbons by a salvo of four guns.

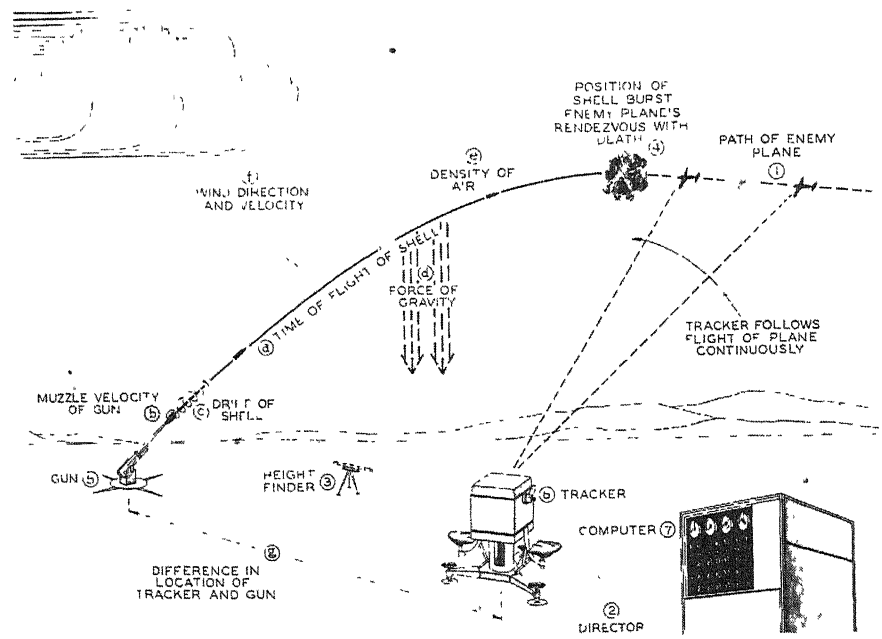
For such fire control consideration must be given to the distance and course which the plane will travel during the several seconds while the shell itself is in flight, as well as to direction, shell velocity, direction and speed of wind, and air density. As the telescopes follow the plane, the Electrical Director gathers information from which it predicts just where its target will be when the projectile reaches it, assuming that the plane flies a straight course as precision bombers must. The Director then selects, with the aid of its built-in ballistic tables, a direction and angle of fire, and a fuze setting, which bring the shell to its rendezvous with the plane and explode it there.

In the art of ranging on a moving object, the Electrical Director has solved the difficult problem of compensating for the errors introduced by the human element. There is a natural tendency for the observers to permit the target to stray from the cross-hairs in the telescopes. Realizing that this has occurred, the observer attempts a quick recovery which may be interpreted as a change in the speed of the target If this information were used, the gun would quickly change its lead to fit the false rate of speed. Engineers of the Bell Telephone Laboratories have invented a brand new method by which the momentary fluctuations are averaged out, and the Electrical Director considers only the smooth rate reported over a period of several seconds

COAL-IN-OIL

May Have Effect on Fuel Shortages

SAVING of many lives of men on torpedoed ships, as well as a large impact on problems of fuel shortage, will result from the use of coal-in-oil fuels, one of the newest combustion developments growing up since the war, John V



How the Electrical Gun-Director works. When an enemy plane (1) looms in sight, the crews of the tracker (6) and of the height finder (3) spot the target and follow it. The computer (7) of the Electrical Director (2) instantly measures the position of the target and then predicts where the anti-aircraft gun (5) is to be aimed and how the fuze of the shell is to be set so that the shell will burst at the predicted plane position (4). Not only does the computer make its calculations continuously while the target is being tracked but it makes constant and continuous corrections for a number of factors. The time of the flight of the shell (a) to the predicted position of the plane is dependent upon the muzzle velocity (b) which, in turn, is governed by the temperature of the powder and the number of times the gun has been fired. The shell's path is also influenced by the drift (c), caused by the spin of the shell. At the same time the pull of gravity (d) deflects the shell downward and the varying density of the air (e) slows down the projectile more or less. The direction and velocity of wind also have their effects (f), retarding or speeding the shell or forcing it to one side. To add to all these variables which the Director must take into consideration, the distance between the gun and the tracker (g) must enter into the final solution of each anti-aircraft directing problem

Pyle recently told members of the American Society of Mechanical Engineers.

Mr. Pyle, manager of the steam division of the Kennedy-Van Saun Manufacturing and Engineering Corporation, described how his company began experiments with "colloidal fuels"—pulverized coal mixed with oil—in 1928, dropped them because fuel was plentiful, but renewed its experiments when the war brought on the fuel crisis.

The saving of lives of men on torpedoed ships will result from the fact that, mixed with carbon, the oil does not remain on the water's surface Hundreds of lives, lost because men plunged from sinking ships into seas of burning oil, might have been saved through use of this fuel, Mr Pyle said

In mixing the pulverized coal with the oil, it is ground "finer than ladies' face powder." It is estimated that 100 million tons of coal waste are discarded annually in the anthracite coal regions of Pennsylvania alone, because this coal has been regarded as too fine for use The ultimate goal is to reclaim all this wastage

LUBRICATION IMPORTANCE

Stressed as a Means of Speeding Production

LUBRICATION engineers, who once devoted their efforts to selling industrial lubricants, are now engaged in a battle against friction, heat, cold, speed, dust, dirt, moisture, and water in the nation's war production factories, the Standard Oil Company of New Jersey revealed recently in outlining some of the unusual ways in which these specialists have speeded up war production through eliminating costly shutdowns, preventing undue wear of manufacturing equipment, and cutting down waste and inefficiency

These specialists study the nation's war machines in actual production, test them to determine if they are operating efficiently, check speed and power output, analyze oils and greases used in their operation, determine gear-operating temperatures, take plaster impressions of gear teeth to determine the extent of gear-tooth wear over given periods and, through engineering analysis, trace causes of shutdowns and breakdowns which, if permitted to continue, might well seriously slow America's output of war materials.

One lubrication engineer not long ago found reduced production in a plant making shells. The delay was caused by the breaking of a die in the shell-nosing department. The trouble was traced to the use of an incorrect die lubricant. When a new compound was employed the shutdowns ceased and production rose substantially.

In a chemical plant making phosphorous for flame throwers and incendiary bombs, production was delayed by faulty lubrication of bearings of the conveyor which carried raw materials to the furnace. The lubrication engineer found that the bearings, subjected to high temperatures, burned out because of an unsatisfactory lubricant. He suggested a high melting point grease. This ended the shutdowns and brought about increased production

A Pennsylvania machine shop's contribution to the war was the manufacture of small parts for gliders Production lagged because in one turning operation the workers could obtain only one piece per tool grind. A lubrication specialist found that the plant was using a cutting oil which was too heavy and lacked sufficient compounding A transparent cutting oil was substituted and the same machine not only produced 20 pieces per tool grind, but the transparency of the product also enabled the operators to see their work at all times

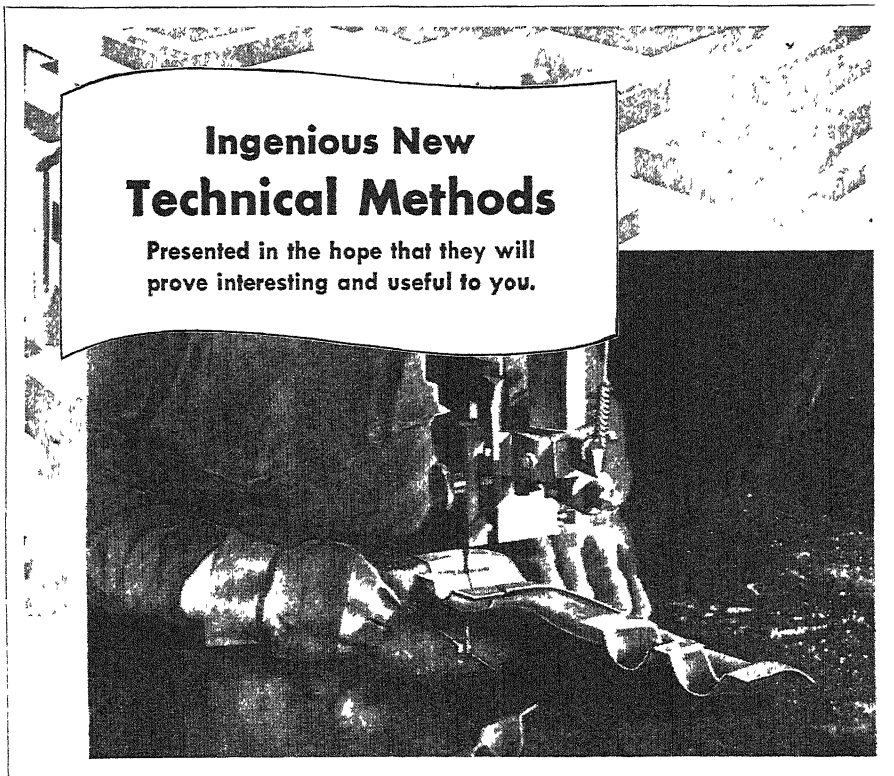
These specialists never know just where they will find trouble nor can they forecast the results of their inspection and study of production problems The problems they encounter and solve frequently have baffled production experts and their work takes them into a wide variety of fields

PNEUMATIC UNLOADING

Conveys Chemicals from Cars to Storage Bins

TYPICAL of what may be accomplished by the use of compressed-air materials handling equipment, operating either above or below atmosphere, is a pneumatic system for unloading and conveying chemicals at the Municipal Water Plant, Lansing, Michigan.

The system makes use of a positive



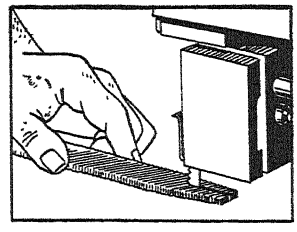
Hard Steels Cut by Heat Generated by Super High Saw Speeds

Ordinary band-saws, when operated at unbelievable high speeds up to 12,000 feet per minute, cut through hard steels and alloys by heat generated from the friction of the saw against the metal to be cut. The cutting effect is more that of burning through the metal than actual cutting. The heat generated is sufficient to melt or burn out the metal in the saw cut but not enough to draw the temper on the sides.

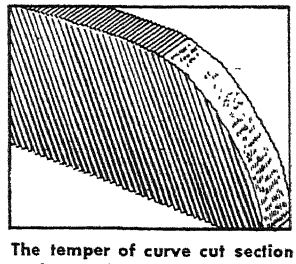
The hardness of either saw or metal to be cut is of little importance. Thin metal sheets are cut like paper, and plates up to one inch in thickness can be cut at speeds of ten inches per minute.

We hope this has proved interesting and useful to you, just as Wrigley's Spearmint Gum is proving useful to millions of people working everywhere for Victory.

You can get complete information about this method from Bell Aircraft Corporation, Buffalo, New York.

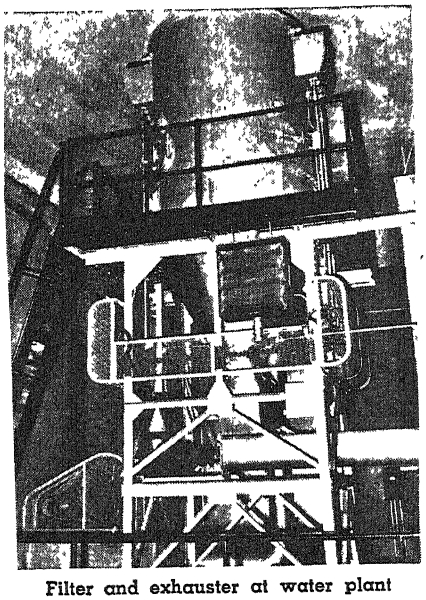


Proof of ability of new method to cut hard materials is demonstrated by operator cutting a file



The temper of curve cut section shown above is unaffected.

X-60



Filter and exhauster at water plant

pressure blower used as an exhauster to produce a partial vacuum that picks up various chemicals from cars and delivers them into a receiver and filter.

The conveying duct is carried underground some 180 feet with a vertical lift of 70 feet to the receiver located above and adjacent to the storage bins.

According to the Compressed Air Institute, this system unloads and conveys to storage bins lime, soda ash, and alum at the rate of 10 tons per hour, with a minimum of labor used to handle the hose in the car, and with complete control and retention of dust. The conveying duct is carried up within the building, taking a minimum of space at the various floors. Similar systems using compressed air equipment, because of their flexibility, may be utilized for the handling of any dry, finely divided, granular or lumpy material.

WELDING TOMORROW

Will Touch Every Human Endeavor

THE GROWTH in arc welding has been so phenomenal in the past three years that it has become "one of the great hopes for rebuilding our war-shattered world," and may revolutionize many aspects of modern living, says J. R. Morrill, Assistant to the Vice President of the Lincoln Electric Company.

"In the world of tomorrow it is not difficult to conceive of new petroleum fuels for power or even atomic power made available and harnessed by arc-welded pressure vessels. The present arc-welded magnesium flying wing indicates possibilities for new methods of transportation. Welding may change the entire world of agriculture by making possible food processing equipment at the site of growing and harvesting. Our clothing is inevitably related to the world of synthetic chemistry to which arc welding is making contributions. Welded skyscrapers and buildings, and prefabricated welded bathrooms and kitchens for the dream shelter of tomorrow are already on the drawing boards.

"Arc welding has grown from a simple repair tool to where few products or structures made of metal are without welds in one form or another—from all-welded ships weighing thousands of tons to clusters of aircraft tubing made of material 25/1000 of an inch in thickness"—*American Society of Mechanical Engineers.*

FLUX-GATE COMPASS

Works Near Earth's Poles, Opens New Navigational Possibilities

TWO BLIND spots on the earth's surface totalling nearly 10,000,000 square miles have been opened up to air travel by one of the most dramatic scientific achievements to come out of the war Anywhere within 1200 miles of either of Mother Earth's magnetic poles, magnetic compasses begin to jive and planes enter a shadowy no-man's-land of lost ships. Around the North magnetic pole this no-man's-land takes in half of Greenland, the northeast corner of Alaska, and most of Canada down to within 250 miles of the United States-Canadian border at one point.

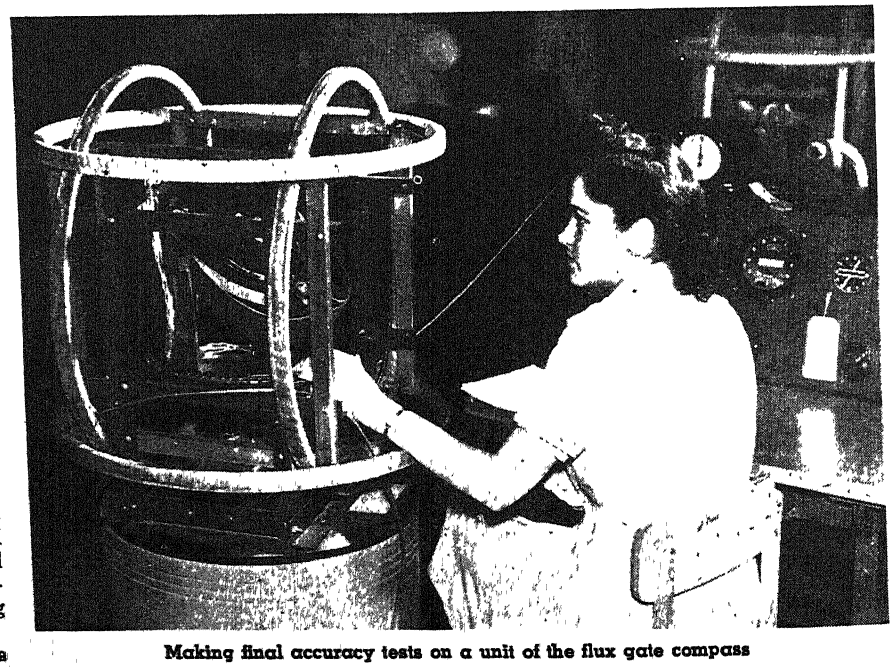
Now, with the gyro flux gate compass, developed by engineers of the Bendix Aviation Corporation, this area has been opened for the fast shipment of war materiel to our Allies and for trans-polar transportation after victory is won. Thus the air freight and passenger routes between continents is shortened by thousands of miles, cutting many travel hours off future weekends in Vladivostok or Christiana.

Three years ago the War Department asked Bendix — manufacturers of Pioneer instruments — to develop a compass that would work in the polar regions. Scientists of the corporation's Eclipse-Pioneer Division gave them what they asked for — and a lot more The new compass permits accurate navigation near the poles and, as an added feature, will not lose its "heading" when the plane goes into a steep dive, climb, or bank. In place of a compass card that "hunts," oscillating with every movement of the ship, the needle of the new instrument points the plane's direction steadily on a dial In a bomber, as many dials as are needed are provided — for pilot, co-pilot, and bombardier — each of them synchronized with the master dial or "mechanical brain" on the navigator's work table With this equipment a navigator can plot a course to almost any spot on the earth's surface with unprecedented accuracy.

The gyro flux gate compass is a far cry from what was for thousands of years the principle of all compasses — the simple magnetized needle that, answering the pull of the earth's magnetism, seeks North. It dates back vaguely to the "earth induction" compass that Pioneer developed in 1927, but it has grown into a complicated partnership of mechanical units, the result of intensive research

Heart of the new compass is the "flux gate" itself which consists, essentially, of three double-wound electromagnets, forming the sides of an equilateral triangle One of the coils

Demonstration model that shows the operation of the flux gate compass



Making final accuracy tests on a unit of the flux gate compass

on each magnet is for the purpose of excitation and is connected to a power source. In the other is generated a fluctuating current as the compass cuts the lines of force of the earth. By the use of the three magnets, properly placed, different voltages are generated in each, according to the angles at which the lines of force are cut. Thus the basis of the indication on the compass dial is the combination of the angles and hence of the voltages generated. The resulting current, amplified by vacuum tubes, is stepped up to sufficient power to turn a motor, the shaft of which moves the needle of the dial. A gyroscope spinning at 10,500 revolutions per minute holds the little flux gate level with the earth. The gyro flux gate unit, however, is not related to the gyroscopic compass used on ships It is entirely different in principle.

Joint authors of the new compass are engineers Alfred Stuart, Paul Noxson, John Emerson, and Don Smith, who worked under supervision of W. A. Reichel, Pioneer's director of engineering.

The War Department has decided that the secret of the new compass can now be told, for though the Germans know about it and have tried to copy it, they simply cannot do the job

RESEARCH

Defined, With a Glance Into the Future

THE PHILOSOPHY of a dynamic economy, perhaps, finds its best expression in the field of research In its broadest sense, research means seeking for better ways of doing things by the most effective use of resources, facilities, and manpower. The spirit of research dispels smugness and constantly searches the unknown in the quest for new and broader opportunities for all. That great practical achievements have been attained is evidenced by the fact that one third of the persons employed prior to the war were in industries that had been created by research in the course of the preceding quarter of a century. The new techniques and tools developed in wartime will have widespread peacetime application. By using the available facilities we can magnify our productiveness, open up new frontiers, and pilot into constructive channels the dynamic and irresistible forces now in motion.

There is no end to progress, for human wants are insatiable and can be fulfilled at an encouraging rate if we but use intelligently the instruments of creation and the vast storehouse of accumulated scientific knowledge at our command.

The shape of things to come will depend in large measure upon how wisely we plot our course No nation has become great by clutching at security or by clinging tenaciously to the past, but rather by boldly venturing into new fields of experimentation and exploration, and by providing rewards commensurate with the risks involved. We should revitalize our enterprise system all along the line so that we may most effectively muster our strength to meet the challenge before us.—*New England Letter* of The First National Bank of Boston.

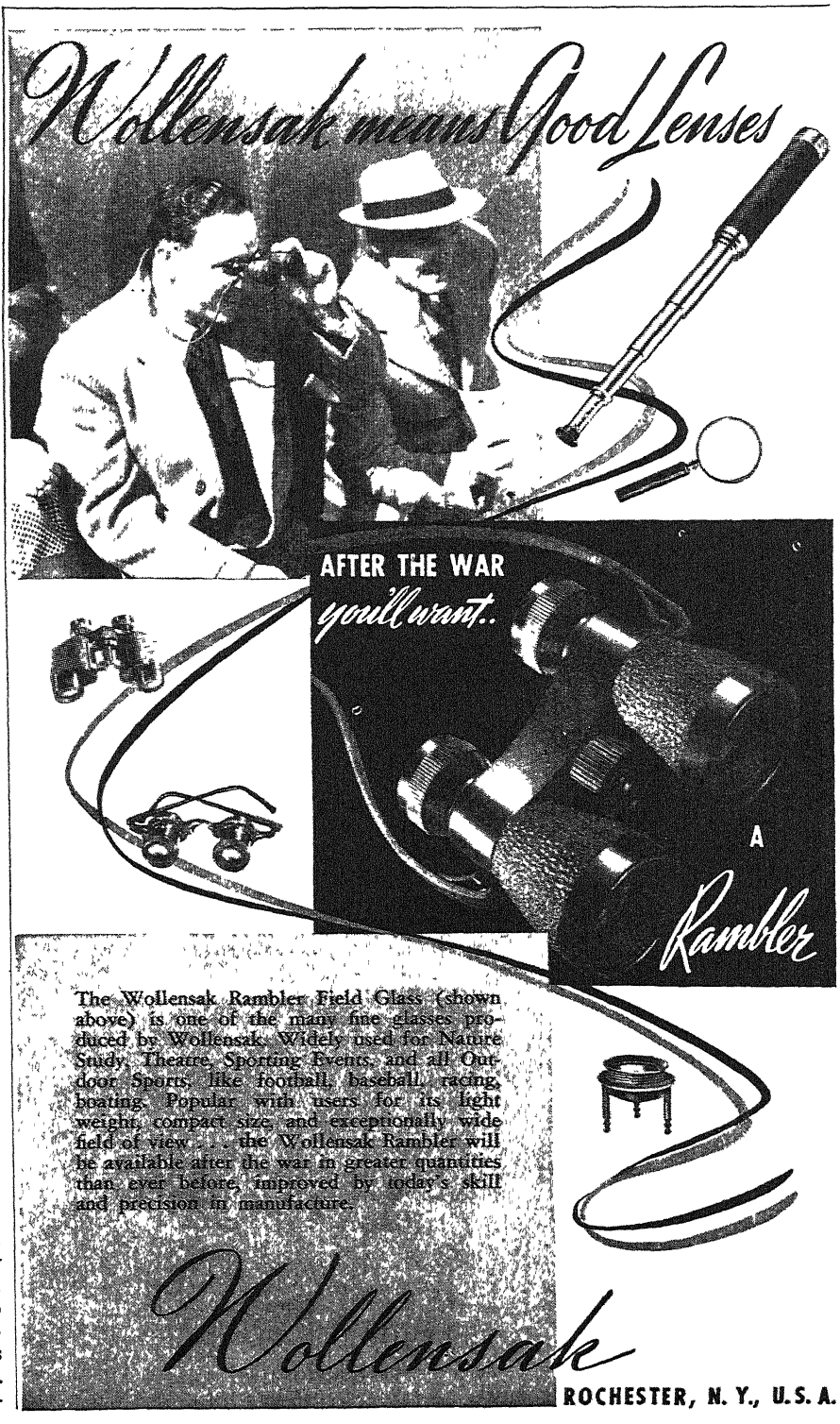
FIRE PREVENTION

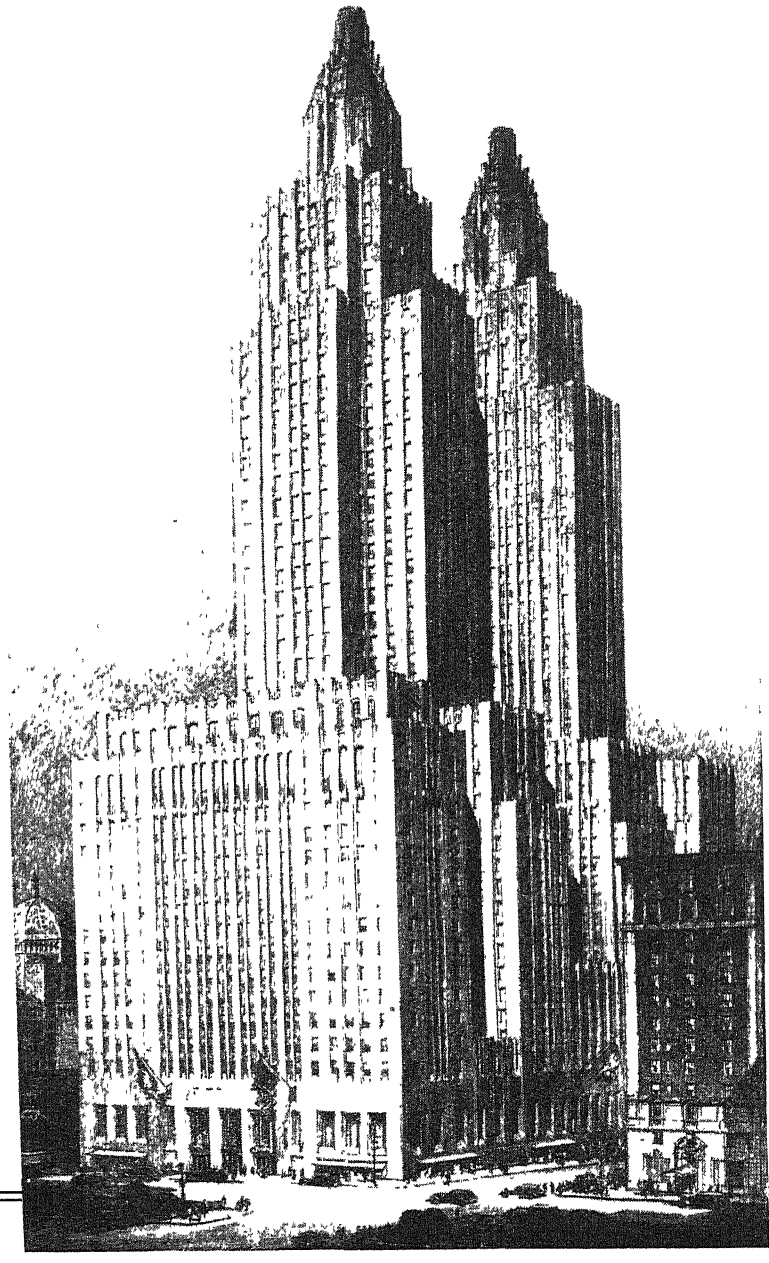
More Important than Fire Fighting

THE MODERN trend in the use of chemicals for the control of fire emphasizes prevention rather than fire fighting, says H. L. Miner, manager of the Du Pont Company's Safety and Fire Protection Division and past president of the National Fire Protection Association

Mr Miner points to recent accomplishments of research in flameproofing everyday materials, noting that paper, cloth, and wood now can be chemically treated to make them incapable of spreading flames. Lumber is being fabricated in large quantities, chemically made so fire retardant that it is classified on a combustibility scale closer to asbestos than to ordinary wood. A recent Underwriters' Laboratories report on this new type of building material states that fire resistance is achieved in proportion to the amount of the chemical—chromated zinc chloride —deposited in the wood.

"Practically all kinds of paper and cloth, including the sheerest fabrics, may now be chemically flameproofed," Mr. Miner says. "Treatment is so effec-





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tive that it is impossible to set such textiles or paper on fire. In fact, no afterglow occurs following the use of a new fire retardant based on ammonium sulfamate Today production is almost entirely devoted to protective garments for the armed forces and for war workers It will render great service in safeguarding life and property in peacetime.

"Research work is in progress in our laboratories to produce fire retardants of a permanent nature," he states "It is no longer necessary to re-treat frequently except after laundering, nor need retardants alter the appearance or stiffen fabrics. But retardants that are sufficiently economical and available today to warrant wide usage still are soluble in water We hope to have better ways of transforming the inherently flammable nature of those many common things that supply the kindling for destructive fires in industry, in public places, and at home"

BOMB FUZE TESTS

Conducted in Miniature High-Speed Wind Tunnel

A THREE-FOOT-LONG wind tunnel which creates 300 to 800 mile an hour gales to simulate the wind currents encountered by falling bombs has been developed by Westinghouse engineers to test fuzes for 20-pound fragmentation bombs, according to A. L Atherton, Manager of Quality Control, who first applied the wind-tunnel tests to these fuzes

"To protect our aircraft which drop them," continued Mr. Atherton, "these bombs are equipped with safety fuzes —small cylindrical devices installed on the bombs' noses. By timing release of a firing pin during descent of the bomb, the fuze prevents premature explosion

"Only when the vane of the tip of the fuze has revolved a pre-determined number of times will the bomb be ready to explode on impact Revolving of the vane loosens a safety device which in turn releases the firing pin to strike explosive portions of the bomb when it hits the ground Unless the fuze releases the firing pin, the bomb will be a dud"

To maintain a constant check on the

Man-made gales test bomb fuzes

quality of fuzes produced, a certain number are taken each day from the final assembly line and tested in the wind tunnel. Their performance is measured by the speed in "arming," or releasing the safety devices To pass the wind tunnel test, a fuze synthetically "dropped" at 250 miles an hour, 500 miles per hour, and 800 miles per hour must arm within a pre-determined length of time.

To test a fuze, a laboratory technician places the fuze inside the narrow three-foot-long tunnel. Then the technician presses a button which starts an automatic timer and opens a magnetic valve. As the valve opens, a burst of air rushes from the tank through a reducing nozzle to the fuze, whirls its vane, and releases the safety device As the safety device flies off, it permits a beam of light to strike a photoelectric cell This causes the cell to electronically close the valve and stop the timer.

Speed of the wind created for each test is determined by measuring the change in the tank's pressure and the time that the valve is open "Arming" time of each fuze is measured by the automatic timer in intervals as small as one hundred-and-twentieth of a second.

MOSQUITO BOMB

Uses Material from Household Refrigerator

USE OF a "mosquito bomb" in mechanized warfare against diseases means certain death to malaria and other fever-carrying mosquitoes. It contains a mixture of pyrethrum extract and sesame oil which is vaporized and ejected under pressure by Freon, a refrigerant used prior to the war in many household mechanical refrigerators.

Used in the "mosquito bomb," Freon produces a high-pressure spray which saturates the tent or dugout of a soldier, tracking down and killing every last mosquito in the area. The soldier can then enter, secure in the knowledge that no malaria mosquitoes are alive The insecticide, moreover, while bringing sudden death to insects, is harmless to human beings

Freon was invented by Dr Thomas Midgley, Jr, vice president of Ethyl Corporation, and is used in refrigerating and air-conditioning equipment It was not until comparatively recently that its strange new war role was discovered —*Ethyl News*

MILDEW PREVENTION

Inexpensive Treatment in Manufacturing Mildew-Proofs Many Products

A NEW technique called the Puratized process, employing a revolutionary chemical formula for the prevention of mildew in paper, paints, plastics, leather, textiles, and rubber, has been developed which effectively renders manufactured products antiseptic and prevents growth of micro-organisms that are causitive agents of mildew. The process can be easily modified to meet specific requirements in many industries. Introduced in early manufacturing stages, no additional plant equipment or extra processing are necessary for its application.

The spores of the fungi which cause mildew are air-borne, either floating freely or attached to particles of dust, and it is difficult to combat them successfully in this state. When they alight on wallpaper, upholstery, carpets, draperies, freshly painted surfaces, leather, fabrics, and other substances on which they can put out roots, the surface becomes contaminated in short order. Treating the material with an ordinary antiseptic is largely ineffective; the antiseptic will kill only existing micro-organisms but will not act as a permanent repellent. The phenols, such as carbolic and cresylic acids, while effective, may not be used on fabrics that are intended to be worn next the skin as they are both irritating and toxic, not being water-resistant their potency is short-lived and is lost when the goods are washed or dry cleaned By incorporating the new process during the manufacture of susceptible materials, however, not only are micro-organisms killed which may be present at the time of treatment but the material is rendered lastingly immunized,even after washing or cleaning

Dr. Frank J Sowa, research chemist for Gallowhur and Company, Inc manufacturers of the Puratized process, after surveying the problems involved in rendering fabric antiseptic as well as imparting lastingly bacteriostatic and fungistatic qualities, determined that the chemical formula required should be such that lasting mildew-resistant properties would be imparted to military fabrics under conditions of field use and, in the case of civilian goods in the post-war era, the treated material would be able to meet all climatic and storage conditions and yet be free from toxic or irritating properties

Dr. Sowa's formulations—there are six variations—have been exhaustively tested.

Not at present generally available

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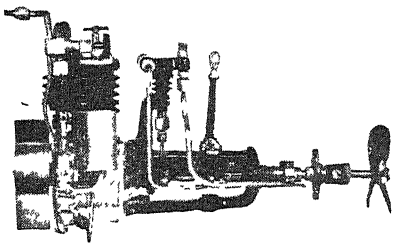

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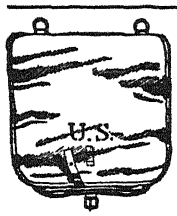

Army Haversacks

heavy canvas, 7½ by 11 inches, with pockets, second hand, with leather sling. Postpaid for 75 cents 1940 75th Anniversary catalog, 308 pages, 2000 illustrations, mailed for 50 cents. 1943 circular for 3c stamp.

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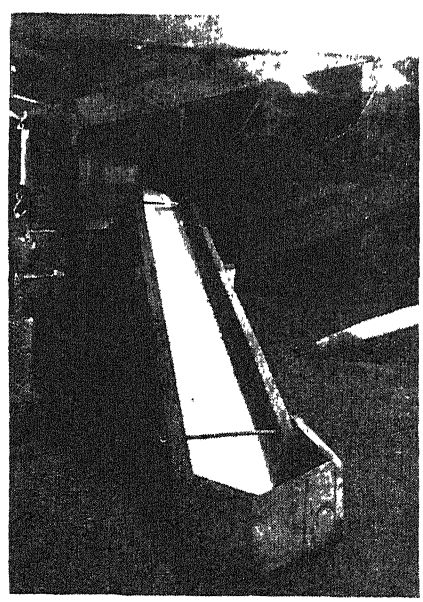
for application to goods intended for civilian use, the Puratized process has been used for treating millions of yards of canvas, mosquito netting, and other military fabrics. Even under the ideal conditions for mildew which are found in the humid jungles in which many of our troops are fighting, material processed by Dr. Sowa's formulations has been found to be definitely fungistatic and bacteriostatic and to have longer serviceability. One formulation has been used in treating over 20 million pairs of shoe linings, not only to eliminate loss from mildew but to act as a safeguard against the shoe lining being destroyed by *Trychophyton interdigtale*, the causative organism of Athlete's Foot.

GLASS CHUTES

Outwear Steel in Coal Handling

FIVE GLASS coal chutes are now in use in the breaker of the Locust Coal Company. Alternate sections of Carrara glass and steel were used for the experiment, making possible an ideal



Glass wears well in coal chutes

comparison between the two materials It was found that the steel plates had to be replaced about every three months due to the wearing through caused by sulfur water and the abrasive action of the coal. After a year and a half, the glass installation is still in use. Although carrying an average daily load of 100 tons, there has been no breakage and very little sign of wear or abrasion. Indications are that the glass will last almost indefinitely.

AIR-CARGO DEVELOPMENT

Planes Should Be Free of Domination by Other Lines

PUBLIC interest demands development of an air-cargo business free from domination by surface transportation companies and independent of monopolistic combines, Dr. John H. Frederick, of Austin, Texas, declared recently before an Air Cargo Meeting of the Society of Automotive Engineers He warned that air cargo should not jeopardize its future by making expedient arrangements with those who may supply coördinating services, whether in airport operation, cargo handling at terminals, or local pick-up and delivery services.

"The public should be told in no uncertain terms," asserted Dr. Frederick, "that while there will have to be certain coordinating agencies between it and the actual transportation of air cargo in the air, air cargo is, and will be, airline business.

Dr Frederick explained that air cargo will take some traffic from rail and motor carriers, and that many marketing and merchandising methods will be changed He said that local and short-haul tonnage will remain the motor carriers' business, long-haul tonnage of raw and heavy commodities the business of the railroads, both in large volume.

"If the ground carriers handle this traffic properly," according to Dr. Frederick, "they will have all they can attend to It would, moreover, not be in the best interests of the public for American transportation to become too much integrated, to merge the competing agencies into huge, monopolistic combines in which the surface interests would inevitably play a dominating part, particularly the railroads with their greater capitalization"

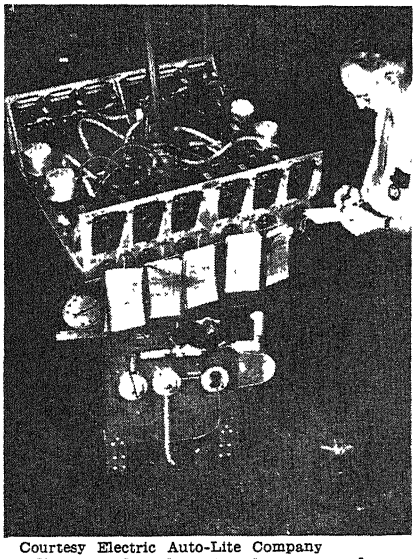
AUTOMATIC PILOTS

Require Utmost Care In Manufacture

FOR MANY years the flying of a plane, even for relatively short distances, required perfect muscular coordination, natural aptitude, and an especially high grade of instinctive intelligence on the part of the pilot. Improvements in the planes, and intensive research on the part of the aircraft instrument industry, have resulted in the development of automatic plane controls, which, at times, are better able than a human pilot to hold a plane to true course.

The full import of this innovation, and its effect upon post-war world commerce and transportation, is the subject of much thought and speculation in the aeronautical industry Following our entrance into the war, however, the immediate task has been the further development and production of these automatic controls for use in military planes. Their importance to the war effort is a story which cannot be told until victory has been achieved, except to say that automatic pilots are required by our armed forces in tremendous quantities.

Known affectionately as "Elmer," by the men whose lives often depend on it, the automatic pilot is truly a "mechanical brain." It is faster and more nearly infallible than the human brain in "thinking" and in introducing corrective forces when a plane starts to deviate from its true course. As might be expected, the manufacture of a device of this kind calls for the utmost precision and extraordinary precautions. Minute particles of dust, if lodged in a critical part of the control, will



Courtesy Electric Auto-Lite Company

Testing the directional gyro under all motions possible in an airplane

prevent proper functioning. Rust and other chemical actions of a degree which is ordinarily of no consequence introduce major problems in the manufacture of this type of product.

Freedom of movement and perfect balance are two requirements which involve highly specialized skill on the part of the instrument assemblers. Stickiness in any degree makes an assembly unacceptable. The cause may be misalinements, poor bearings, or poor finishes on vital parts, rust or dirt on pivots or bearings

Because of the vital part played by the ball bearings and pivots in automatic pilots, these ultra-precision parts are processed and inspected in a white tile lined air-conditioned room where the utmost precautions are taken to prevent rust, dust, and mishandling from causing bearing troubles on the assembly floor. Special lint-free uniforms are worn and dust counts are regularly taken to insure that bearings washed microscopically clean remain so until removed from sealed cellophane bags and assembled safely in place as part of the instrument. High precision measurements made on 100 percent of the pivots and bearings serve to eliminate fitting operations, with attendant dirt-gathering possibilities, in the assembly department.

RESEARCH MANAGEMENT

Requires Increased Expenditures To Insure Keeping Pace

RAPIDLY changing conditions require that more money be spent for research and development by the medium-sized chemical company, according to C L. Gabriel, vice president of Publicker Commercial Alcohol Company, in a paper presented before a Symposium on Research Management sponsored by the Division of Industrial and Engineering Chemistry of the American Chemical Society

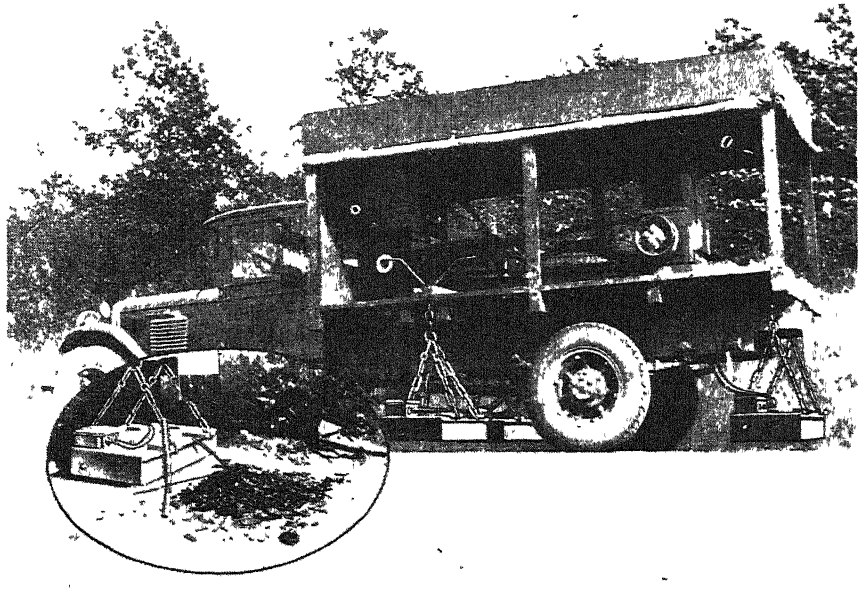
Between 5 and 10 percent of the annual profit of a company making a profit of from $3,000,000 to $15,000,000, before Federal income and excess profit taxes, should be devoted to research and development, in the light of swift technological advance and high taxes, Mr. Gabriel said.

Improvement in processes, utilization of by-products, new uses for products already manufactured, new chemicals to round out lines of products sold to various industries, and new developments which may possibly have nothing at all to do with the company's immediate business should be included in the subjects of research, according to Mr Gabriel.

ROAD CLEANING MAGNET

Helps in Conservation of Automobile Tires

A ROAD cleaning magnet recently developed by Cutler-Hammer is mounted on a truck; three magnets can cover a road span of eight to nine feet, drawing any metal in the path. The magnets are best operated when suspended to within two to three inches of the ground, since then they can draw subsurface material from loose ground. An



Three magnets on a truck. Inset: "Sweepings" from a roadway

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SOLE MATERIAL

Produced by Processing Unused Leather

SUCCESSFUL development of a new process of manufacturing shoe sole material, which may help solve the nation's shoe leather shortage, was announced recently by the Russell Manufacturing Company. This new material

Crude material and finished sole

is produced by processing parts of fine leather hides, not generally used, with trolene, a secret chemical compound developed at the company laboratories The resultant product is reported to be comparable in many respects to high grade leather.

Tests made by the United States Testing Company, Inc., showed the new product, known as "Trolene-ized" leather, to compare favorably with high quality sole leather in flexibility, abrasion resistance, resiliency, moisture absorption, and certain other characteristics. These tests also disclosed some factors of superiority, such as the fact that this material is water-proof in high degree without being air-tight; and also that it has a high coefficient of friction which reduces the danger of slipping

PACKAGED POWER

Opens New Possibilities In the Transportation Field

A COMPLETE, self-contained "packaged power" unit, combining a six-cylinder, horizontally opposed aircraft engine with all accessories, plus a clutch and flywheel, into a single, self-cooled package, has been developed by Lycoming Division of The Aviation Corporation.

The fact that this unit is completely self-contained and that it weighs less than one-third as much as existing power plants of comparable output used in busses and other motor driven vehicles currently operating on American highways indicates important post-war as well as current uses.

A salient feature in this respect is the fact that, being air-cooled, it is immune to temperature extremes, such as those encountered during winter highway operation in Northern Canada and in the high heat of southwestern deserts. The new unit has been operated successfully under test conditions at 120 degrees, Fahrenheit, and at 20 below zero over protracted periods

The engine has a dry weight of 755 pounds and develops 162 net horsepower at 2800 rpm on 73 octane fuel at sea-level atmosphere. It was designed for enclosed, or submerged, installation The principal element of the cooling system is a cast aluminum fan, or blower, mounted integrally with the flywheel and having an outside diameter of 28¼ inches The 16 blades of this fan have airfoil shape. About one-half the volume of air propelled by the blower is used for cooling purposes and the balance to maintain ample air supply to the carburetor at a pressure above atmosphere on the intake side of the heavy-duty air cleaner

According to Lycoming engineers, later developments in this "packaged power" field already have forecast further considerable reduction in both weight and cooling system power consumption Weighing one-third the weight of current motor bus engines of comparable horsepower, this complete power plant also has the advantage of the usual aircraft engine characteristic of being designed to operate constantly at 75 to 85 percent of full power

PLASTICS APPLICATIONS

Critical Factors Numerous, But Wide Use Probable in Future

PLASTIC materials are only temporarily limited in their engineering applications and already possess characteristics which make them increasingly attractive to designers and engineers, according to speakers at the Materials Meeting—War and Post-War—of the Society of Automotive Engineers

Characteristics of plastics as engineering materials were discussed by W. F. Bartoe and Dr. D. S Frederic, of Rohm and Haas, who said that such qualities as low weight per unit volume, ease of fabrication, low thermal conductivity, available transparency, and low unit cost for mass production entitle plastics to consideration for every application. Ease of fabricating complex structures, they added, already has led to the manufacture of one-piece plastic bomber noses, one-piece plastic gun turrets, intricate manifold forms, and complex forming dies.

Development of more comprehensive engineering data on plastics was reported to be helpful in extending uses, but the speakers warned that factors other than safety margins and more critical than those affecting metals must be considered. These factors include stress, dimensional changes with time, required service temperature ranges, and effects of temperature on physical properties.

Service temperature ranges were characterized as extremely critical, differences of as little as five to ten degrees demanding choice between thermosetting and thermoplastic materials, and determining the eventual success of the application.

What Glass Is And Isn't

(*Continued from page 23*)

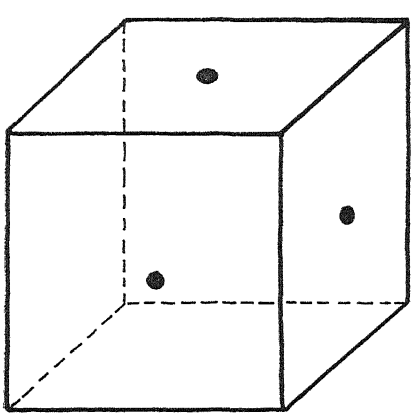
by the action of fire on earthy materials of one kind or another. These earthy materials, which may be rocks or minerals, are composed largely of silica and the silicates The result of exposure to high temperatures may be glass as one extreme, an aggregate of crystals as the other, but very often it will be a mixture of the two. When certain ceramic bodies are fired, some of the more fusible minerals melt and form glasses which act as a bond between the unmelted grains of the less fusible minerals. There are indications that many clay products have properties almost wholly dependent upon this vitreous matrix. The reasons underlying these changes in the earthy materials are found in the complicated physical chemistry of the silicates. For our purpose we need only point out that Morey's definition of glass, quoted above, can be supplemented by saying that commercial glasses are ceramic products, chemically related to the silicate minerals, and physically related to all other vitreous substances

WHAT'S A LATTICE?

Some Considerations Involving A Corner of Physical Chemistry

In the preceding article the author refers to the face-centered cubical lattice of sodium and of chlorine ions in sodium chloride. The first of the accompanying drawings shows diagrammatically a face-centered cubical lattice Its three atoms are respectively at the center of the top, side, and front faces of the cube

The second drawing represents the

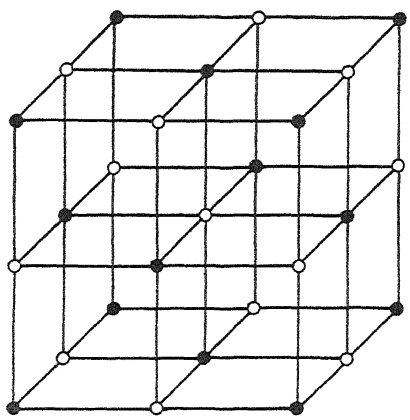


A face-centered cubical lattice

arrangement of atoms within a space lattice of the cubically crystalline mineral halite—sodium chloride, or common salt, Na Cl.

The solid dots represent sodium ions and the circles chlorine ions. It is, of course, unlikely that atoms or ions actually have these shapes. Science does not yet know what atoms would look like if they could be made clearly visible. X-ray diffraction experiments made on large numbers of atoms give results which can be best interpreted as indicating that, in crystalline matter, these atoms are "concentrated" in fixed, regularly repeated positions, much like a wallpaper pattern but in three dimensions rather than two. Most matter has been found to be crystalline, built from immense numbers of these small three-dimensional units.

In his article the author points out that if we wish to retain the idea of the molecule, we are still unable, in the example he cites, to isolate individual sodium chloride molecules, and that therefore the whole salt crystal is really a single gigantic molecule Now, in the



Atoms within a lattice of salt

mental concept of a sodium chloride molecule one sodium atom is linked to one chloride atom, the two constituting one molecule. So let us examine the drawing (second sketch) and see whether this will work We select one sodium atom (black dot) and then locate for it one chlorine mate (circle). This proves to be easy but at once five other chlorine neighbors at exactly the same distance protest, 'Why pick that one? Why not some of us?'" (If the drawing were extended by adding additional lattices in all directions, as in crystals of matter, it would be clearer that there are no exceptions to this situation, except at the very edges.)

We could, of course, arbitrarily assign one particular chlorine to one particular sodium, like men and women in dinner couples around a table, but Nature makes no such convenient assignation. There is, therefore, no such actual entity as the sodium chloride molecule Nor is this a mere quibble over words. Each sodium has six chlorine neighbors, not merely one, each chlorine atom six sodium neighbors. It smacks of communism, polygamy, polyandry.

What the drawing therefore shows is the interpenetrating space lattices of chlorine and of sodium, together forming the compound sodium chloride.

Sodium chloride is commonly selected for diagrammatically demonstrating these elementary facts of physical chemistry because its system of crystallization is so simple—neat, symmetrical, cubic. Some other compounds that might be employed would not be quite so accommodating in the matter of simplicity. In other words, not all matter, or even a majority of it, is cubically crystalline.—*A.G.I.*

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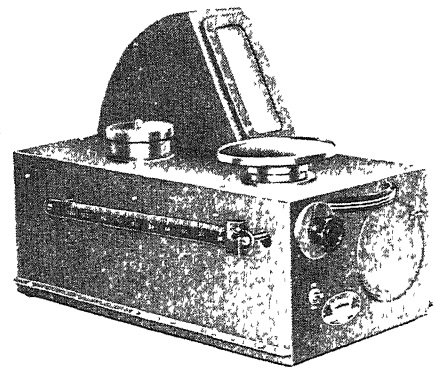

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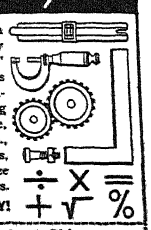

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HOW TO SHIP BY AIR EXPRESS DURING WARTIME is a 12-page illustrated pamphlet, file size and with file tab, which lists the data needed when applying for a shipping priority, gives weight and size specifications, and delineates the advantages of air express shipments. *Railway Express Agency Inc., Department of Public Relations, 230 Park Avenue, New York, New York. —Gratis.*

CYCLOGRAPH is an eight-page illustrated folder describing in considerable detail the operation and the uses of the electronic instrument mentioned in the article on page 10 of this issue. *Allen B. DuMont Laboratories, Incorporated, Passaic, New Jersey.—Gratis.*

AUTOMOBILE FACTS AND FIGURES is a yearly publication, the 1943 edition consisting of 64 pages of important tabulations, presented in both graph and tabular form. This year's report, of course, deals largely with the industry's war effort. *Automobile Manufacturers Association, New Center Building, Detroit 2, Michigan.—Gratis.*

METAL CUTTING SAW BLADES is a 20-page pocket size booklet describing hand and power hack-saw blades and giving diagrams and hints on the correct and incorrect ways of using such blades. *The Capewell Manufacturing Company, Hartford, Connecticut.—Gratis.*

THE MULTI VAL LUBRICATING SYSTEM is an eight-page illustrated bulletin describing an improved method of providing positive lubrication to a group of bearings from a central distributing block. Photographs and drawings show how the system can be installed on a wide variety of machines. *The Farval Corporation, 3249 East 80th Street, Cleveland, Ohio.—Gratis.*

MAKING DEMOCRACY AND THE WORLD MUTUALLY SAFE, by Arthur Graham Glasgow, is a 44-page pamphlet based upon a half century of worldwide engineering experience. The greater part of the text is devoted to a discussion of the abuses discrediting democracy and of proposed remedies *The Secretary, 1900 Monticello Avenue, Norfolk, Virginia.—Gratis.*

TELEVISO AIRCRAFT AND INDUSTRIAL MEASURING INSTRUMENTS is a 48-page illustrated catalog, divided into five sections covering aircraft gyro test instruments, aircraft vibration test instruments, aircraft industrial production testers, industrial vibration measuring instruments, and electro-mechanical laboratory and production test equipment. *Televiso Products, Incorporated, 6533 North Olmstead Avenue, Chicago 31, Illinois.—Gratis.*

A HISTORY OF PREFABRICATION, by Alfred Bruce and Harold Sandbank, is an 80-page lavishly illustrated booklet covering the whole general field of prefabrication of buildings and the manner in which human requirements are met by developments in structural technique A glimpse is given of future possibilities. *John B. Pierce Foundation, 40 West 40th Street, New York 18, New York —75 cents.*

THE METAL CLEANING HANDBOOK is a 72-page technical manual on materials, methods, and machines for wartime metal cleaning. The text provides an organized means of selecting the material and method best adapted to various kinds and shapes of metal articles *Magnus Chemical Company Inc., Garwood, New Jersey —Request this bulletin on your business letter head.—Gratis.*

DUST—THE SILENT SABOTEUR OF PRODUCTION is an eight-page bulletin describing the hazards of dust to specific industries, with recommendations for control at the source *American Foundry Equipment Company, Mishawaka, Indiana.—Gratis.*

PRODUCTION MANAGEMENT is a 32-page booklet describing in simple and non-technical language the application of one system of production management which has been applied in a large number of manufacturing plants. The objective of such work is the increased utilization of manpower resources and of plant facilities. *The Bedaux Company, Incorporated, Chrysler Building, New York, New York.—Gratis.*

FLAME HARDENING MACHINERY is a folded bulletin describing and illustrating equipment for this type of work, as well as special machinery for bending, broaching, and drilling Request Bulletin SM 843. *Hydraulic Machinery Incorporated, 12825 Ford Road, Detroit, Michigan.—Gratis.*

ASHES MAKE POOR GUN POWDER is an illustrated pamphlet which tells something of the little-known things that fire insurance companies do to aid a nation at war. These things concern specialized phases of engineering, research directed toward reduction of fire hazards and damage by fire, and so on. *National Board of Fire Underwriters, 85 John Street, New York 7, New York.—Gratis.*

New Products

"DEHYDRATED" HOUSEHOLD PRODUCTS

A MANUFACTURER of household repair products has developed a line of "dehydrated" products for household use, based on the same principle as the dehydrated soups, drinks, and other food products as used by the United States Armed Forces The manufacturer claims savings in packaging materials, including metals; ease of use and conservation of vitally needed household items which cannot now be replaced.

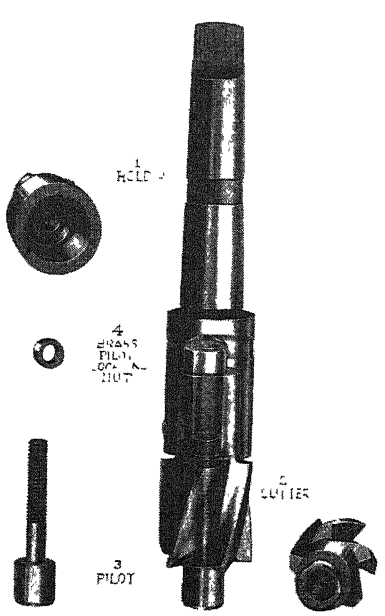
The manufacturing company, So-Lo Works, Inc., states that there are 20 household repair and maintenance products now on the market in the new form and that others are being planned. A few of the "dehydrated" products are cements for mending furniture, glass, stoves, rubber articles. Also there are paint removers, silver polishes, rust preventers, wood plaster, and so on.

CONVEYOR BELT

GENERALLY comparable in all respects with pre-war high quality conveyor belts, a new super-quality synthetic-rubber conveyor belt by Goodyear has the additional advantages of resisting oil and high temperatures Designated "Style SS" type, Goodyear's new conveyor belt is adapted particularly to all mining operations, including coal, metals, and similar materials, and to the transportation of gravel and aggregate of all kinds.

SHEARPROOF DRIVE

UTILIZING the eccentric principle in its design to equalize the torque load on the holder and the mating driving member of the cutter, Moreland Tool Company announces production in a range of sizes of a shearproof counterbore drive. The driving member of the cutter fits into a spherical off-center hole in the holder, both shank of cutter and corresponding hole in holder being round in shape and eccentric in location only. Without any sharp edges, pins, or wedges, this method of coupling cutter and holder eliminates any tendency to shearing action—it is practically as strong as a piece of solid bar stock of the same diameter and analysis



Phantom view of holder and cutter

PASTE SPREADER

A NEW linoleum paste spreader, known as the Victory Spreader, is made of tempered board with 35 deep-recessed teeth It is claimed by the manufacturer, Allmetal Weatherstrip Company, that the material used in this product is water and acid resistant and that the spreader is definitely stronger and more durable than other substitutes for metal spreaders

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A NEW general-purpose synthetic rubber sponge, made in three densities, has good oil resisting properties, and can be made in slabs, cord, tubing, or in almost any other molded shape. The grades correspond pretty well with pre-war crude rubber sponges.

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SETS OF new master setting and checking rolls for the checking of micrometers and other precision inspection and gaging instruments consist of 20 individual rolls ranging from 100 to 2.000 inches in diameter The rolls are hardened, ground, and lapped to gage makers' X tolerance. They are deep frozen before finish grinding to eliminate internal strains and provide accelerated ageing

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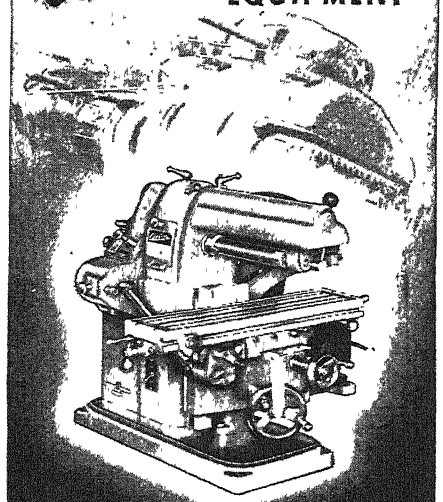

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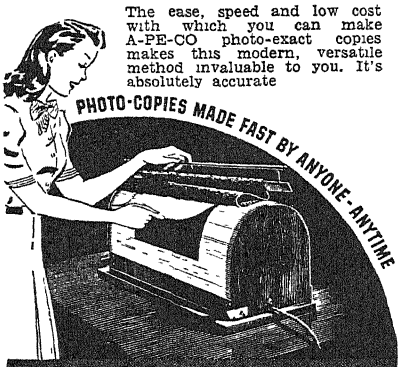

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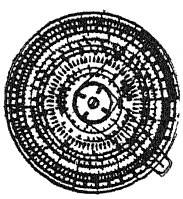

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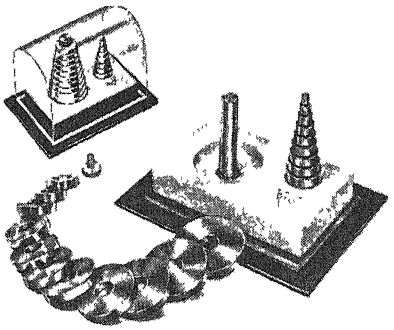


Master setting and checking rolls

might show it accurate, while actually the instrument might be out considerably at the point of greatest wear. Sav-Way setting and checking rolls provide a convenient means of making 20 quick, accurate checks throughout the entire range of the instrument at one time.

In addition to checking, these rolls are extremely useful in setting up jobs where dial indicators and amplifiers are to be used.

ANGLE COMPARATOR

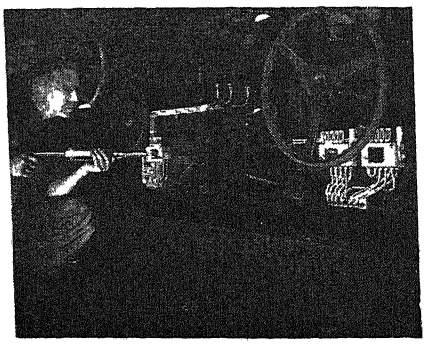
THE CHIEF purpose of a new Angle Comparator is to afford a rapid method for comparing dihedral angles, which at the same time possesses a high degree of sensitivity This method was developed particularly for use in the processing of prisms for mass production work, but may also be used for comparison work of other glass or metal parts.

The instrument is so constructed that it may be used with parts of various sizes, and may also be used when prisms are cemented together in the form of a stick. A simple adjustment of a few screws is all that is necessary in changing from one size to another. The range of the present instrument is for parts whose faces are approximately 1 inch square to 4 inches square; but the instrument may be easily altered to accommodate parts of smaller or larger dimensions. The instrument, made by the Optical Engineering Laboratories, may be set to compare angles from 45 degrees to 135 degrees

MACHINE LUBRICATION

POSITIVE lubrication of all bearings on machine tools and similar equipment, regardless of location or condition of bearings, can be had through the improved "Multival" system made by the Farval Corporation Oil or grease under pressure is delivered to the distributing blocks by means of a manual or power-operated portable gun which serves as a central pump

Complete Multival equipment consists of multiple valve blocks, each serving two to ten bearings, lubricant lines leading to individual points, and suitable fittings to accommodate practically any type of bearing connection. The systems can be readily installed by shop maintenance crews Each measuring valve can be individually adjusted to deliver the exact amount of lubricant required by the bearings it serves.

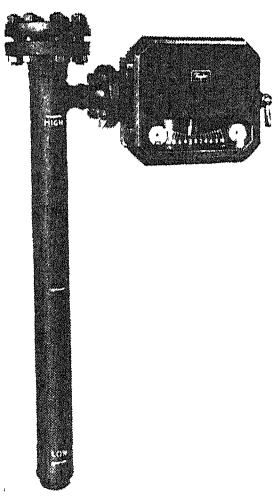


"One-shot" machine lubrication

LEVEL-BUOY

WITH THE announcement of its new Level-Buoy the Taylor Instrument Companies adds to its line a buoyancy-type instrument which both controls and indicates liquid level The new instrument employs the Taylor Fulscope Control Mechanism with either completely adjustable sensitivity for smooth throttling level control, or automatic reset for averaging of liquid level with a minimum disturbance to the process.

A torque tube transmits the level changes to the instrument mechanism



For controlling and indicating liquid level during industrial processing

This eliminates a stuffing box with its need for lubrication or packing and gives a closed system which eliminates leakage The torque tube in interchangeable with the ones used in the Taylor aneriod manometer. There are no internal parts to cause friction or wear

SPATTER-PROOFING

WHILE there are various methods of protecting work surfaces from weld spatter, many of them are either satisfactory makeshifts or require special washing for removal. Now there has been developed, by G. W. Smith and Sons, a compound for spatter-proofing which not only protects work surfaces but also is reported to have fluxing qualities which improve the operation of any electrode and provide stronger welds.

This spatter-proofing material, known as Protect-O-Metal, is brushed or spread into the seam and onto surrounding surfaces. During the welding

operation the compound in the seam fuses with the molten metal, reputedly removing oxides and impurities from the weld. After welding, all spatter, surface oxide, and residual compound are removed quickly with a damp cloth.

FLEXIBLE FASTENER

THERE HAS been added to the long list of vibration absorbers a new device, known as the Packless Flexible Fastener, which has the combined functions of a supporting strap and a vibration absorber for stationary or movable tubing It was developed at the request of aircraft builders who desired a simplified and improved hose strap that would eliminate the whip of hose in airplane engines.

The fastener consists of a sensitive spring, cone-spiraled and terminating in a clip which snaps on to the tube or similar unit to be fastened. It is affixed to a supporting surface by means of a standard or wood screw fitted through the cone. Inasmuch as it flexes in all directions, the fastener can be installed in either lateral or vertical position Its small hose area both facilitates placement and gives a large working area to the cone

On corners, the fasteners can be systematically set so many inches apart in order to prevent tubing bends from making abrading contact Upon any impact, the fastener compresses into its cone, thus cushioning the hose against injury.

While designed originally for aircraft use, the fastener is as well adapted to application in the railway, refrigeration, and scores of other industries.

FOR METAL PLATERS

Two new products for covering plating racks were recently announced by Goodrich One is known as Koroseal Tape RX, while the second is Koralac RX, a solution of Koroseal. In some applications the two are used together, with the tape being applied after the rack has been coated with the solution; in other cases they may be used separately.

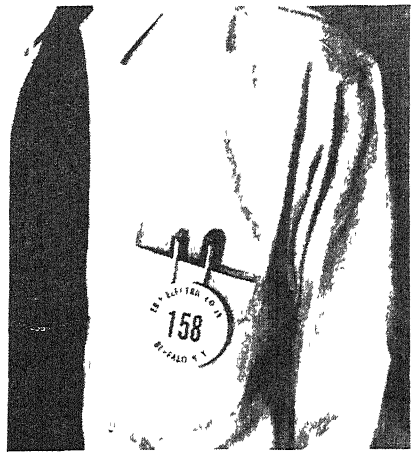
Koroseal Tape RX possesses good resistance to wear and abrasion, has excellent insulating properties, and can be used for practically all kinds of plating service, since it has resistance to all plating solutions, including chromic, alkali, and acid dips

No special equipment is needed when Koroseal Tape RX is used in conjunction with Korolac RX solution, the rack being first treated with two or three coats of the solution and the tape then wrapped under firm tension, after which one or two more coats of the solution are again applied. If the tape is used alone, the rack must be placed in an air oven with a minimum temperature of 300 degrees, Fahrenheit, for two hours after the tape has been applied This fuses the tape together

The plating rack solution Korolac RX provides a corrosion resistant, tough, inert coating with good insulating properties, satisfactory for nearly all kinds of plating rack service. Liquid at room temperature, it holds its position on the racks after application because of shrinkage as the solvent evaporates

POCKET PROTECTION

SHIRT, coat, and vest pockets may be protected from the wear-and-tear of pen and pencil clips through the use



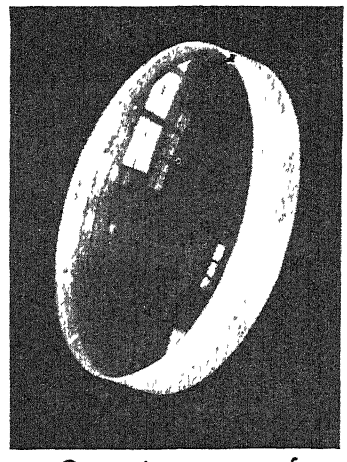
Protects pocket, holds badge

of a new and inconspicuous transparent plastic pocket protector developed by Hurley Smith. The protector, as shown in the illustration, also provides a place for attaching a war-plant badge, thus eliminating pin holes in garments.

WAX ALTERNATE

To MEET the growing shortage of micro-crystalline wax, Wishnick-Tumpeer, Inc., announces the development of Witco Hamp Wax, a new group of waxes for use in the manufacture of Ordnance wraps and other military and essential civilian products.

This new product is a hard amorphous petroleum wax of the greaseproof type, which possesses an exceptionally high resistance to moisture vapor transmission. Its general uses are for waterproofing ends of bags for export shipments and for manufacture of Ordnance papers and similar applications where melting point, hardness, and other properties of this range are desired It should fill a genuine need for an alternate to micro-crystalline wax



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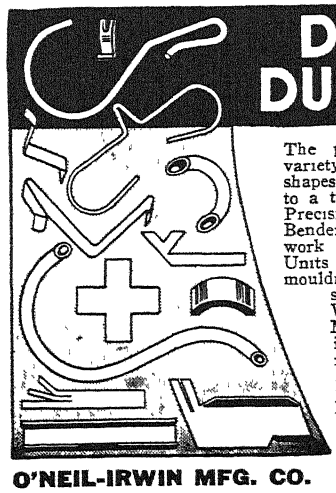

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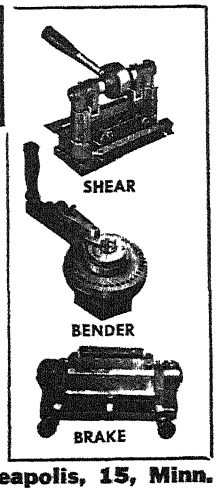

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Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS
Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

IN REFLECTING telescopes, seeing is often hampered by "temperature effects" within the tube. In the valuable contribution that follows, one amateur telescope maker, F. N. Hibbard, of the U. S. Weather Bureau Office at Richmond, Va., describes experiments on various types of tubes, made with J C. Vaughan of Petersburg, Va.

"Bell's book, 'The Telescope,' 'A T.M.,' and many other books tell what a stellar image may look like and what it should look like A good image of a star, under a power of 40 or 50 times the telescope aperture in inches, and under good seeing conditions, will be a perfectly round disk, of a size varying inversely as the diameter of the objective according to the Dawes formula, with the disk surrounded by a series of concentric rings of graded intensity. On rare occasions of exceptional seeing, the rings will be needle fine like the web of a spider.

"Deviations from this perfect image, assuming the mirror to be well figured and supported by ample leverage, can

Figure 1: The common set-up

usually be traced to a pinched or imperfect prism, improper alinement of the optical train, a poor eyepiece, a possible warping of the mirror by changing temperatures, unsteady air, imperfect eyesight, or temperature differentials in the telescope tube.

"These defects, their images and their remedies, have been well covered by writers—with the exception of temperature differentials. The latter, otherwise known as 'tube effects,' have been cussed and discussed for years, without any final agreement as to remedy, and, curiously, without exactly spotting the underlying cause. One writer says he likes a metal tube; another says a better image is possible with a lined tube; a third suggests the use of a fan on the tube to mix the tube air into uniformity of temperature; another mentions the superior performance of a wooden tube, particularly after the panels had been removed.

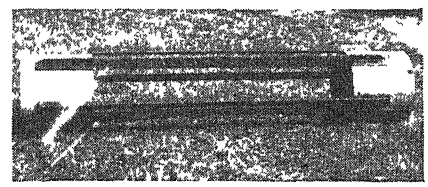

Figure 2: Wrapped skeleton tube

"It is not generally known, outside the Weather Service, that various substances or materials exposed in the open air under a clear night *attain temperatures different from that of the surrounding atmosphere* Repeated experiments prolonged for months show that thermometers so exposed consistently register lower-than-air temperatures, differences amounting generally to several degrees and occasionally as much as 8°. They further show that the differences persist for hours at a time. In other words, objects exposed to the clear night sky seldom attain the temperature of the air, but differ from it and from one another.

"To conceive the process by which two contiguous substances, such as air and metal, can attain and maintain such an anomalous thermal condition for hours together is difficult. It depends, however, principally upon the individual absorption and radiation properties of the substance.

"With this background, we are ready to see what happens in a telescope tube.

"My first experiment was to use an 8" mirror in a solid metal tube open at the upper end. (Figure 1). The air next to the metal of the tube chilled and drained down the tube, producing differential refraction of light and a poor image.

"The second experiment consisted of lining the tube with cork, asbestos, and paper. This left the air in the tube warmer than the outside air. As the chill of evening advanced, a mixing of this warm air with the cooler outside air at the mouth of the tube again produced images distorted to some extent.

"The third experiment consisted of boring holes in the cork and metal of the upper part of the tube to afford drainage of the tube air to the outside before it reached the mouth of the tube. This experiment showed that cool air from the outside drifted through the holes, and each wisp of cool air caused a streak across the stellar image.

"The fourth experiment was made with the same mirror placed in a skeleton tube built of six angle irons. Theoretically, this tube should have given a splendid image, as the air inside and outside should have had the same temperature. But, alas for science, the more sense I used the less she worked. Air drifting through the tube between the metal work became chilled by the metal, produced a different refractive index, and again left streaks across the image

"The fifth trial was carried out by wrapping the same metal with thick paper (Figure 2) and painting the paper a dead black. This improved the image to some extent but bad images still resulted In fact, the images some nights with this skeleton tube were quite intolerable, and well-known features of the lunar topography at times were obliterated. The effect of the chill of the metal was proved by placing a heavy cardboard lining within the tube, shutting off the wisps of air chilled by the iron. The moment the cardboard was in place, the images entirely cleared themselves of streaks and became passibly good. This experiment was tried over and over until the evidence of differential temperature was proved beyond question. The conclusion was inescapable that the ironwork had an entirely different temperature from that of the air, and that the difference persisted hour after hour.

"The final experiment was to use a solid metal tube, line it throughout with a quarter-inch thickness of cork, and cut a large hole of about 20 square inches in the tube just above the mirror to ventilate and cool the mirror. This gave excellent results, particularly when the hole was covered before observation to steady the inside air. The mirror was a wonderful piece of work and it cut doubles down to the Dawes limit time after time.

"By this time my friend, James C. Vaughan (Figure 3) of nearby Petersburg, Va., and I had decided that a larger mirror would be a fine thing to have, particularly for nebulae and clusters. So we prevailed on J. W. Fecker to fix us up with a mirror 12⅜" in diameter, which proved to have a magnificent figure. We decided to continue the temperature control experiments with this larger mirror, and built for it a skeleton tube (Figure 4) of duralumin, designed so that it could be converted easily into a closed tube when so desired Observational results were identical, except that the larger tube, which was 15" or 16" in diameter and had relatively less metal, showed relatively smaller chilling effects. Differential chilling and differential re-

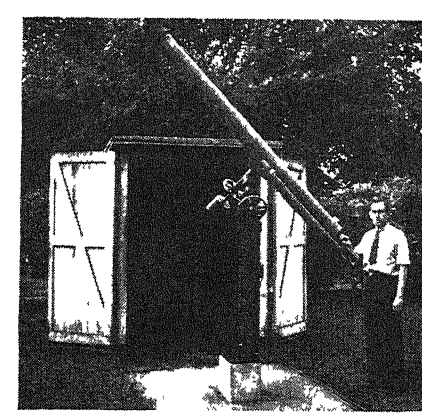

Figure 3: Vaughan, collaborator

fraction were slightly less, but were not eliminated until this larger tube was lined completely

"In constructing this large lining, it was found that even a small crack or hole would produce a tiny ribbon of light across the image, the ribbon shifting erratically as the wisp of air drifted about within the tube Spaces between the ends of the wooden lining and the metal work had to be calked with cotton or wool Ample ventilation for the tube was provided underneath the mirror, but the mirror itself was protected from the direct draft When we finally cut the vents through the cork lining of the cell, cold air from the cell felt like the discharge from an opened refrigerator

"These experiments show us rather clearly what the 'tube problem' is, why the tube walls should be well separated from the cylinder of light entering the tube, why a skeleton tube does frequently produce unsatisfactory streaky images; why a tube must be ventilated, why a lined tube gives better results than a bare metal tube; and why a wooden tube, particularly if well ventilated and held solidly in alinement, does and should give excellent images. These deductions probably do not apply to telescopes housed in a dome but may apply to some extent to the dome itself and its surroundings.

"Several kinds of wood may be used to advantage in making tube linings, but my preference is Douglas fir or balsa, which are light in weight and have low thermal capacity and high insulating properties."

Cogitating on these matters, as a question in physics, independent of telescoptics, your scribe wondered if, then, a given object would not take on the temperature of the surrounding air if given *plenty of time,* and asked Hibbard, whether (to choose an extreme case) Tutenkhamon's toes after 3000 years in his tomb wouldn't assume the exact temperature of the air in the coffin. His reply:

"In a practical way, I should expect enclosed objects to have about the same temperature, such as Toot's toes. But I could arrange Toot *in the open air* so that each foot would have a separate temperature and neither foot exactly that of the air. Apparently, radiation of heat to a clear cloudless sky at night by suitable materials gives the maximum favorable conditions for temperature differentials. There is a rich field for quantitative determinations of variation, which has not yet been explored.

"Experiments in this field should bring out rather interesting relations between color, material, condition of surface, whether matte or polished, and changes that occur when night finally becomes day. I should expect most objects, particularly with a black matte surface, to become warmer than the air under daylight sunshine. The extreme heat of railroad rails on a hot day seems to point to an actually high temperature and not entirely to rapid transmission of heat from rail to finger when the rail is touched by finger.

"The lower temperature of metal at night under a clear sky would not be expected to obtain during the day.

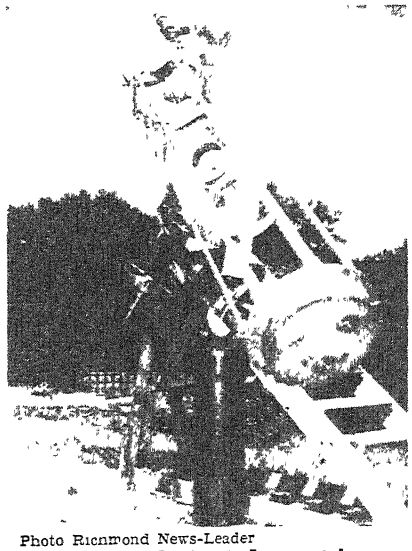

Photo Richmond News-Leader

Figure 4: Hibbard. Larger tube

The situation would be reversed. And this brings us back to the original statement that the temperature of a body depends on the *relative* rates of its absorption of heat from surroundings and its radiation of heat to its surroundings, principally the sky. There necessarily would be moments, if not longer periods, when metal and air were at the same temperature."

A noted meteorologist to whom the above discussion was shown added the following: "A material object will not necessarily reach the temperature of the surrounding medium, no matter how much time is allowed It would, provided molecular conduction were the only influence acting to transfer heat; but in nature this is never the case. Among other influences, one that is always operating is radiation.

"Any object is always continually gaining heat by at least two processes, radiation and conduction, and also continually losing heat by both of these processes An equilibrium temperature is reached when the rate of gain from the combined action of both radiation and conduction equals the rate of loss. In general, this equilibrium temperature will not be the temperature of the surrounding medium.

"*Within an enclosure,* however, with uniformly heated walls, the temperature would become uniform."

Tutenkhamon was "within an enclosure," hence not an ideal illustration since a telescope mirror is partly enclosed, partly open.

In his letter Hibbard makes other comments. He votes for a gear drive with a 359-tooth gear on the polar axis, which makes possible a simple gear combination for sidereal time; a rotating tube, or eyepiece end rotating about the tube axis, which is easy to make and greatly adds to convenience in observing; four small holes in either end of the tube for the occasional use of cross-hairs, or threads, in checking alinement; and solid eyepieces, which give brilliant images and no ghosts despite their small field. He has a ½" triplet aplanat eyepiece that gives absolutely colorless images of such difficult objects as Venus.

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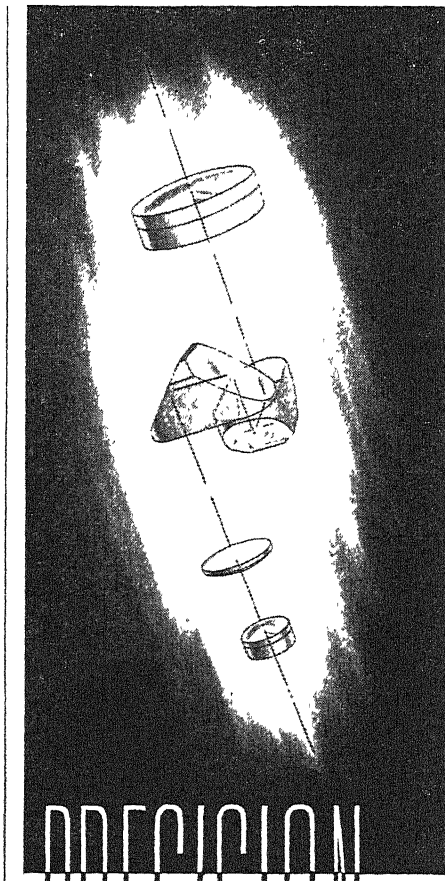

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Save it! Put it in the bank! Put it in life insurance! Pay off old debts and don't make new ones Buy and hold War Bonds Then your money can't force prices up But it can speed the winning of the war It can build a prosperous nation for you, your children, and our soldiers, who deserve a stable America to come home to Keep your dollars out of circulation and they'll keep prices down. The government is helping—with taxes

"Now wait! How do taxes help keep prices down?"

We've got to pay for this war sooner or later It's easier and cheaper to pay as we go And it's better to pay more taxes NOW—while we've got the extra money to do it Every dollar put into taxes means a dollar less to boost prices So .

Use it up . . . Wear it out . . . Make it do . . . Or do without

A United States war message prepared by the War Advertising Council, approved by the Office of War Information, and contributed by the Magazine Publishers of America

Previews of the Industrial Horizon

By A. P. Peck

SHALL RESEARCH BE REGIMENTED?

THERE IS no need to hold forth here on the value of research to the world in general; the technological progress of industry is ample proof of that value. Despite this, however, there is now before Congress a vicious bill—the Kilgore Bill (S. 702)—which, if it becomes law, will throttle without mercy those incentives which have always been the very basis of industrial research and its resulting benefits to mankind.

Briefly stated, the Kilgore Bill would create, under the guise of war-time need, an omnipotent "Office of Scientific and Technical Mobilization" for the alleged purpose of correlating and disseminating the results of research, purportedly for the benefit of everyone, as well as for conducting research programs under its own government-controlled wing.

On the face of it, as is usual with much ill-advised legislation, some of the objectives of this Bill appear to be worthy of support. But more intensive study reveals many undesirable features What the terms of the Bill could easily bring to pass, in war or peace, would be complete domination, control, and regimentation of *all* research, removing this vital work from the hands of private enterprise and concentrating it under a political set-up This would unquestionably spell the doom of our established system of free enterprise and industry Take away the research facilities of industry, place them in the hands of appointed governmental employees, where initiative and incentive are lacking, and you destroy the very backbone of progress.

Then, too, the proposed OSTM would provide an ideal pork-barrel, subject to the whims of the party in power, from which would be drawn far more parasitical political patronage than scientific and technological progress.

There are only a few, a very few, highlights of this proposed legislation and its outrageous shortcomings. If the Kilgore Bill becomes law, the people of this nation are going to pay through the nose. Research will be stultified—as so often has been the case in isolated attempts at government-controlled research. Progress under such an all-inclusive program would come slowly if at all. And industry, under such law, would find itself severely handicapped, to say the least, in the application of research—the one most important tool which it has developed through the years to a point where it has paid huge dividends to industry and to the public alike.

Here, then, in the Kilgore Bill, is an attempt at all-embracing regimentation at its political worst. Efforts to abort the Bill will be efforts directed toward the upholding of the American Way.

SURPLUSES ONCE MORE

RECENTLY reported and verified metal surpluses are giving rise to optimism in some quarters Stock-piles, both private and governmental, of aluminum, copper, molybdenum, magnesium, cobalt, steel, and others, are full to overflowing, full beyond any emergency and immediate needs. Because of existing controls, however, it is doubtful whether much of these metals will find their ways into even essential civilian uses for some time to come. Still too close for forgetfulness are the hectic days of drastic shortages; still too far off is the certain outcome of the war.

WHEN THE GAS TURBINE?

FIRST proposed a century and a half ago and periodically "re-invented," the gas turbine still largely evades the grasp of the engineer. Recently, much publicity has been given to this form of prime mover, resulting in a number of misconceptions and false impressions. True enough, a few gas turbines have been built and are in operation, but only in large sizes where their efficiency rises to reasonable values But in smaller sizes—as for motor cars and small planes—the gas turbine still remains in the indeterminate future

Limiting factor in the design and construction of gas turbines, as mentioned in the article on page 73, is lack of knowledge about materials for use at high temperatures And strangely enough, as greater knowledge is gained in this field, it is equally as applicable to increasing the efficiencies of steam turbines and Diesel engines as it is to the problems of the gas turbine When competitors thus gain equally, the net result is maintenance of *status quo*

The technological race still goes on, and while the time may approach when the gas turbine will be able to compete on equal footing with established prime movers, it is as yet beyond the horizon.

ANOTHER USE FOR CANS

WHILE on the subject of metals, this is as good a place as any to note, for future consideration, a use for tin cans that will create a new market for these ubiquitous containers When metals are once more available for these lowly cans, they are going to crack the field of packaging dehydrated foods The tremendous amount of study that has gone into this type of food and the lessons that have been learned the hard way about troubles with them, all point toward the need for more perfect packaging Cans can do this job. File this prediction until after the war is over

DOWN ON THE FARM

MECHANIZATION—real and thorough mechanization—of the farm is one of the bright spots for heavy industry in the future. Already proved are new designs for highly efficient self-propelled combines, cotton pickers, sugar-beet harvesters, and a host of other machines. One machinery manufacturer, going whole hog, has set for himself the goal of producing a complete set of mechanized tools for the small farm, the whole to sell for not more than $1000.

BUILDING BOOM

ESTIMATES from informed sources indicate that there will be a potential demand for almost 1,000,000 new private dwellings per year for at least five years after the war Here alone is one market where new materials, new products, new methods, will find an outlet for the greatest good for the greatest number.

PAINTS FOR MANY PURPOSES

PIGMENTS with vastly increased hiding powers, more effective rust-inhibiting primers, improvements in resin-base paints that are thinned with water, infra-red reflecting paints—improved surface finishes for many uses—are some of the things to be looked for in the not far distant future

Most interesting of these things to come is the infra-red reflecting paint, since it not only serves the usual purposes of a surface coating but is otherwise valuable. Buildings painted with it are cooler when the sun shines directly on them; evaporation from storage tanks for gasoline and other volatile liquids is reduced through its use; and other heat-reflecting problems can be solved with it.

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of February, 1894)

CANAL TROUBLES — "The Panama Canal still remains in a state of ruin An extension of the concession has been obtained from the Colombian government up to October, 1894, and attempts have been made to form a new company to go on with the work, but so far without success. The Nicaragua Canal is also in difficulties Owing to the state of financial matters in America, it was found impossible to raise money to go on with the work, and in order to protect the works and plant, the Nicaragua Canal Construction Company was placed in charge of a receiver."

QUICKSAND FOUNDATIONS — "A novel method of making foundations in quicksand was described by Mr. F Neukirch. . . The sand on which the foundation is to rest is converted into solid concrete by blowing into it, by air pressure, dry cement in powder The concrete formed in this way takes several weeks to harden, and requires months to attain its full strength."

ICE — "The Knickerbocker Ice Company, of Philadelphia, for many years engaged in the business of harvesting, delivering, and shipping ice . . . has recently established in Philadelphia a large plant for making ice artificially. . . . This new establishment . . . has a capacity of sixty tons of ice daily. The company has sought to make this plant a model one for the production of artificial ice."

COATING ALUMINUM — "At a recent meeting of the Berlin Physical Society, Professor Neesen demonstrated a method of coating aluminum with other metals. This consists in dipping the aluminum in a solution of caustic potash or soda . . . The metal is then placed in a solution of salt of the desired metal. A film of the latter is rapidly formed and is so firmly adherent that, in the case of silver, gold, or copper, the plate can be rolled out or polished."

WATCH — "A remarkably cheap watch has just been put on the market by Messrs R. H. Ingersoll and Brothers . . It is a stem winder and setter, American lever, 240 beats to a minute, steel pinions, patent escapement and regulator, and dust-proof case, handsomely finished in nickel or gilt The watch is fully guaranteed for one year."

WIRING — "The underground electrical conduits in New York City have now a length of 1,667 miles. In these conduits there are about 32,600 miles of telephone and telegraph wires and 1,300 miles of wires for lighting purposes, with which about 6,790 arc lights and 268,000 incandescent lamps are connected."

MANGANESE STEEL — "Manganese steel plowshares wear six or seven times longer than chilled cast iron shares. . . . It is believed that chilled cast iron railway wheels run about one-third the mileage of manganese steel wheels before the first turning"

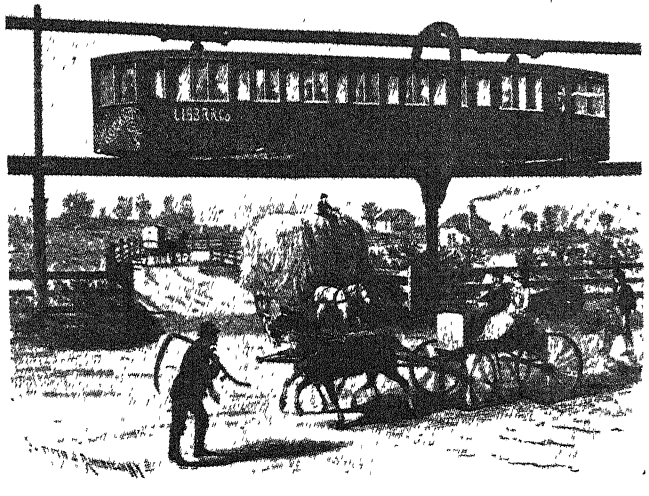
INDUSTRIALISTS — "It has long been our boast that America was able to produce better results in the technical field than those due to any other nation, even where hand work is concerned, this is believed to hold true in many respects. . . . It has long been remarked that where originality and an ability of thinking and working on independent lines is involved, the foreign highly specialized workman yields to the more independent American mechanic, as to one less hampered by tradition. Thus we find our country abounding in self-made men who began at the lathe and bench, and now own and conduct great factories Their independent habits of thought have opened for them their careers."

TRANS-CHANNEL — "There is at the present moment a question of a new project having for its object the connection of the European continent with England by railway . . The solution under consideration is proposed by Sir Edward Reed, a member of the English Parliament and engineer in chief of the Admiralty His project consists in the establishment, under water, of one or more metallic tubes capable of giving passage to a railway . . . In case of war, there would be numerous means of inundating the tubes immediately"

ALLOY — "Mr H N Warren, of Liverpool, England, has been experimenting lately with aluminum bronzes, and has found that the presence of a very small admixture of boron makes a denser and more durable alloy. This aluminum boron bronze casts and melts well, and is free from some drawbacks met with in working with the ordinary aluminum bronze"

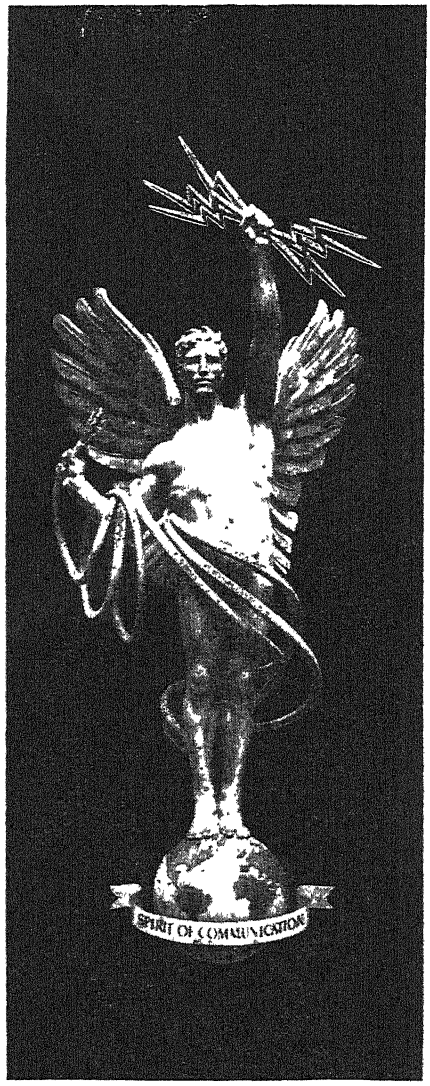
TELEPHONE — "On the 30th day of January, 1894, the Bell telephone patent expired and the invention became the property of the public; so that whoever desires to do so can make, buy or sell telephones without fear of infringing the rights of any one. This applies only to the hand instrument now used as a receiver. Patents for other telephone apparatus still remain in force, but enough is available for actual service"

BICYCLE RAILWAY — "The need of the day is rapid transit Steam, cable, and trolley cars each in their own degree contribute to this end The illustration shows one of the developments in true rapid transit—the Boynton Electric Bicycle Railroad—of which a line is now in process of erection across Long Island, from Bellport to the Sound The idea of the bicycle railroad is to provide a system of transit whose speed may be from seventy-five to one hundred or more miles an hour. Air resistance being one of the most adverse factors at this velocity, a car of small cross sectional area is preferable. The inequalities of two parallel lines of rail is also a factor of resistance. In the railroad in question a narrow car with sharpened ends is employed, and is mounted upon two wheels, one at each end, and travels upon a single rail. It has the equilibrium of the bicycle, and like the latter disposes at once of the violent transverse wrenching strains which affect four-wheeled vehicles of the everyday type It is peculiarly well adapted for electric propulsion, the overhead rail giving a place for the current main."



BEET SUGAR — "The problem of handling waste waters from beet sugar factories is by no means settled. The water residuum, most to be dreaded, comes from the diffusion battery and pulp presses. In some special cases, where there is a scarcity of water, this waste water must be used over again Notwithstanding the precaution of purification, such as employed, after a reasonable time the salts, etc., not eliminated give considerable trouble during manufacture."

A NEW RESOURCE HAS BEEN DEVELOPED



THE WEALTH of America has been wrought from her natural resources of fertile lands, wide forests and rich mineral deposits by the brains and muscles of her people.

But another resource is now available. A new source of wealth and well-being has been developing gradually and almost unnoticed which is tremendously important today and of still greater importance for tomorrow.

This new resource is the research laboratory.

Today, in hundreds of industrial and college laboratories, trained minds are expanding the world's knowledge, and applying the results of research to industry and to war.

In the Bell System, research has always been a fundamental activity. The telephone was invented in a research laboratory. And for years Bell Telephone Laboratories has been the largest industrial laboratory in the world.

Underlying modern research is the realization of vast latent values in nature. Although the lone genius does from time to time bring to light some part of these hidden values, only organized scientific research can assure the thorough exploration that will render the full measure of use for human welfare.

Research means imagining and experimenting. It means the searching out and bringing together of facts. It means clear statements of problems, precise measurements and keen analysis. It means tenacious following along unexpected paths.

These are the procedures of research. Its consummation is the grasping by subtle minds of relationships in nature no one has previously known. And on the basis of the broader knowledge so established are built new materials, new methods and new structures to serve the people of America.

The Bell Telephone Laboratories has now concentrated its efforts on communication systems and equipment for the armed forces. When the war is over its researches in communication will again be applied to an ever-improving telephone service in America.

BELL TELEPHONE SYSTEM

An Important Message to

Technical Men

The war has carried the manufacturing age to a new peak! Production demands have created technical problems the like of which the world has never seen before! The services of engineers are at a premium. Especially the services of one particular class—executive engineers—*engineers with business training;* engineers who can "run the show."

In these critical times, the nation needs engineers of executive ability *now, today*—not five, or ten years from now! The shortage of such men is acute—even more acute than that of skilled production workers. And company heads, aware of this situation, are offering high rewards to engineers who have the necessary training in industrial management.

Golden Opportunity for Engineers

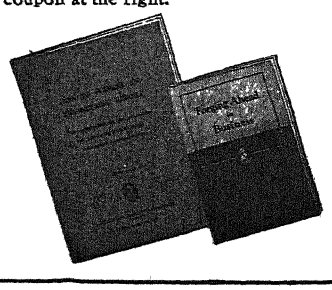
In this new era, the engineer with vision and foresight has a golden opportunity. He will realize that out of today's tremendous production battles will emerge technical men who not only will play a major role in winning the war, but who also will be firmly entrenched in key executive positions when peace comes.

However, before the engineer can take over executive responsibilities, he must acquire knowledge of the other divisions of business—of marketing, accounting and finance. He has of necessity a vast amount of technical training and experience. But in order to grasp the opportunities that present themselves today—to assume leadership on the production front—he must *also* have an understanding of practical business principles and methods.

The Alexander Hamilton Institute's intensive executive training can give you this essential business training to supplement your technical skill.

FREE help for engineers

Ever since the war began, there has been an unusually heavy demand on the part of our technically-trained subscribers for the Institute's special guide on "How to Prepare an Engineering Report". Extra copies of this practical, helpful 72-page Guide are now available and, for a limited time only, will be sent free to all technical men who use the coupon at the right.



134,000 men on the operating side of business have enrolled for this training. More than 37,500 are technical men—engineers, chemists, metallurgists—many of whom are today heads of our huge war industries.

This training appeals to engineers because it gives them access to the thinking and experience of the country's great business minds. It is especially valuable to such men because it is basic, not specialized—broad in scope, providing a thorough groundwork in the fundamentals underlying *all* business. It covers the principles that every top executive must understand. It applies to all types of industrial organizations, because all types of organizations are based on these same fundamentals.

Business and Industrial Leaders Contribute

The Institute's training plan has the endorsement of leading industrialists and business men. And it is only because these high-ranking executives recognize its value and give their cooperation that such a plan is possible. Among those who contribute to the Course are such men as Frederick W. Pickard, Vice President and Director, E. I. DuPont de Nemours & Co.; Thomas J. Watson, President, International Business Machines Corp.; James D. Mooney, President, General Motors Overseas Corp.; Clifton Slusser, Vice President, Goodyear Tire and Rubber Co. and Colby M. Chester, Chairman of the Board, General Foods Corp.

Send for "FORGING AHEAD IN BUSINESS"

The facts about the Institute's plan and what it can do for you are printed in the 64-page book, "Forging Ahead in Business". This book in its own right is well worth your reading. It might almost be called a handbook of business training. It is a book you will be glad to have in your library, and it will be sent to you without cost. Simply fill in and mail the attached coupon *today.*

Alexander Hamilton Institute,
Dept. 35, 73 West 23rd Street, New York, N. Y.
In Canada, 54 Wellington St., West, Toronto Ont.
Please mail me a copy of the 64-page book—"FORGING AHEAD IN BUSINESS" and also a copy of "HOW TO PREPARE AN ENGINEERING REPORT," both without cost.

Name.....

Business Address.....

.....

Position.....

Home Address.....

"Quotes . . ."

"FOREIGN and domestic demand indicates that post-war business will attain record proportions The necessary controls, however, must be applied with discretion and understanding. There must be no ceiling upon the successful prosecution of business enterprises if we are to achieve full re-employment of the men in the Armed Services." Lawrence Ottinger, President, United States Plywood Corporation

" " "

"GRATIFYING PROGRESS has been made in the war on accidents But the battle against carelessness still is far from won, and even greater effort must be made to win it" *Franklin D Roosevelt*

" " "

"COAL IS the predominant source of heating fuel. How soon we will have to depend almost exclusively on it for heating depends on how much oil and natural gas we still can add to our present dwindling supplies. Some day, to be sure, coal has to carry the full load" Robert M. Weidenhammer, President, Cosgrove Coal Company.

" " "

"FACTS ARE indispensable, but they are not enough Unrelated miscellaneous facts, however odd, quaint, or amazing, are not knowledge, in spite of any impression to the contrary given by the Quiz Kids or Information, Please. The characteristic of knowledge is organization, which implies understanding, ordering, and interpretation." *Dr Robert Maynard Hutchins, President of the University of Chicago*

" " "

"YOU MAY expect that five years after the war every community in the country will be within an hour's drive from a point of passenger air service. Most communities of 10,000 population and up will have passenger service and smaller communities will have direct mail and cargo service through pick-up or, possibly, helicopter" C Bedell Monro, President, Pennsylvania-Central Airlines

" " "

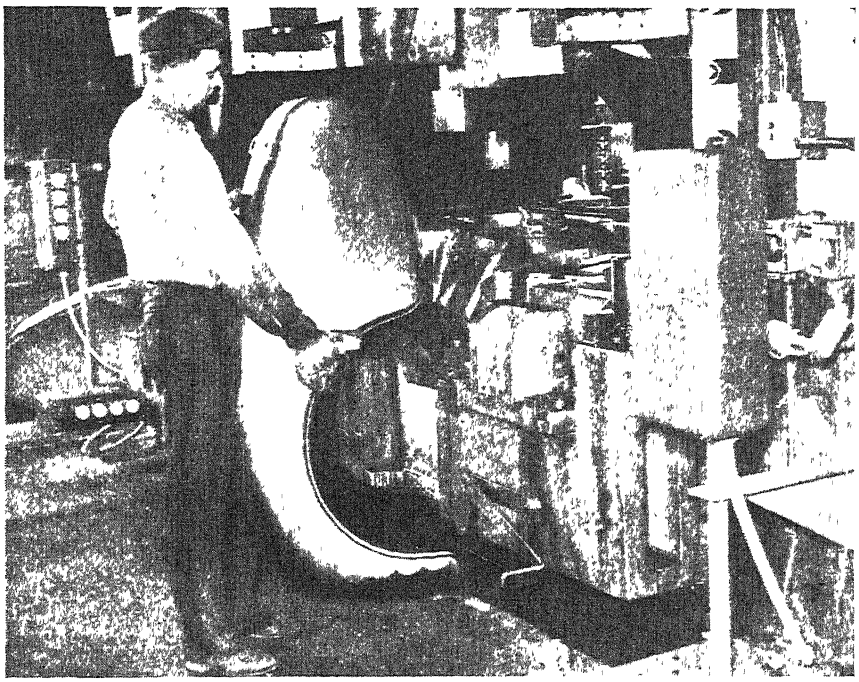
"CERTAINLY there is no more potency in applied chemistry than there is in any other science. The plain fact is that industry has, in recent years, plowed back a larger amount of its earnings for development, improvements, and extension than most others" *C. A Higgins, President, Hercules Powder Company.*

" " "

"BUSINESS AND other leadership groups must act not only in the light of what is water on their own wheel, but also as to what powers our whole economy. They must recognize that the day of rugged individualism—the day of making moves without regard as to who was hurt—are gone, never to return." Chester J. LaRoche, Chairman, War Advertising Council.

ELECTRONICS

Conducted by KEITH HENNEY



Curtains of light assure worker safety. The horizontal light curtain near the floor assumes control in the event that the operator steps completely inside the vertical curtain. The photocell and light housings for both curtains are at left and right

Supercontrol By Electronics

Because of the Versatility of the Electron Tube—and of the Electron—Physical and Chemical as Well as Electrical Quantities Can Be Measured. And When Quantities Can Be Measured, the Variations Detected by Electronics Can Be Translated into Accurate Control Processes

MANY OF the important industrial jobs done by electron tubes come under the general heading of "measurement and control." The tube is a superlatively sensitive and delicate means of measuring not only electrical quantities but chemical and physical quantities as well. And once one can measure a variable, it is comparatively simple to turn the measuring method into a control system. For example, it is not at all difficult to make a tube measure the output voltage of a generator or other source of electric potential. Having made the measurement, it is easy to make any variations in this potential into a control which may be fed back into the generator, or other source, with the purpose of counteracting the tendency of the potential to change. In this case the electronic apparatus acts as a voltage regulator. There are many similar examples.

The electron tube is such a superlative agency for measuring and control largely because the tube requires almost no power to make it do the job. A fraction of a watt—a few microwatts, in fact—are all the input power required to make a tube operate. The great virtue of this characteristic is the fact that the circuit in which the measurement or control is taking place is not disturbed by the presence of the electron tube.

Then, too, an electron tube will operate in a fraction of a microsecond because of the extreme lightness and mobility of the electron. Since the electron has so little weight or mass, it has very little inertia and can be turned around in its path or started or stopped in its flight, at extremely high speed. To illustrate this point, consider a 1000-megacycle generator in which the electrons reverse their direction of motion in less than a thousand millionth of a second.

Another reason why tubes are so effective is the fact that they can exercise extreme smoothness of control. No matter how fine a rheostat one makes, it still controls electric current in jumps or broad steps. A tube, however, will control current to a fraction of a thousandth of an ampere.

Still another tube characteristic is its ability to amplify electric voltages or currents. Furthermore, it can be made to act as a rectifier, conducting current only in one direction. Other tubes convert light energy into electric energy (phototubes), still others convert electric energy into light energy (cathode-ray tubes). Also, tubes will operate on alternating or direct currents, will convert alternating to direct current and vice versa, will convert power from one frequency or voltage to another, will mix two frequencies so as to make one act as the carrier for the other, or will separate two frequencies apparently hopelessly intermingled.

One of the first control applications of the electron tube in the laboratory, and later in the shop, was in temperature supervision. An oil bath, for example, can have inserted in it a bimetallic strip or thermostat. When the oil cools, electric contacts actuated by

the thermostat turn heat into the bath But the current which may be handled by the contacts is not very great and, besides, with constant making and breaking of currents, the contacts tend to pit or to stick together Furthermore, the bath might be some combustible material; here an electric spark at the contacts would be disastrous

The simple remedy is to use a tube The contacts of the thermostat merely change the voltage on the control electrode of an amplifier tube The change in voltage causes a change in the current output of the tube and this change can be as great or as little as desired or needed The tube then turns on the heat. A set-up of this type will control temperature to within 0 1 degree, Centigrade

In another simple system a beam of light shines through the glass stem of a thermometer. As the mercury rises, it obscures the beam and a phototube which ordinarily receives the light sent through the thermometer, no longer is illuminated. The change in phototube current stops the heating mechanism.

There are many variations of this simple scheme, some very complex, maintaining temperature within very close limits over long periods of time

MEASURE, THEN CONTROL—In every case the first thing the tube does is to measure something (voltage in the case of the amplifier, illumination in the case of the phototube) and then this measurement is transferred into a control function

Automatic leveling of high-speed elevators was another early application of tube control Again, two general methods are employed, one using an amplifier tube and the other a phototube. In each case the elevator cage may carry the tube apparatus. Suppose it is a phototube. When the car is to stop at a given floor, the operator pushes a button. This turns on a light near the desired floor, when the elevator car approaches this location, the phototube "sees" the light, and the current change in its output sets in motion the leveling mechanism so that the car stops at the exact spot desired.

Suppose the tube is an amplifier with two coils of wire coupled together. The current which the tube passes is a function of this coupling. If the coupling between the coils changes, the current changes. At the push of the control button, a small metallic vane pops up at the proper location in the elevator shaft When the cage approaches, this vane comes between the two tube coils, the tube current changes, and the leveling mechanism comes into action.

In each case the tube measures and then controls Also, in each case the amount of electric power released or changed by the device is minute, not sufficient to accomplish much useful work. But a tube, or tubes, interposed between the actuating device and the final work to be done can amplify the electric power as much as is desired.

Anything that varies in magnitude can be measured by a tube of one sort or another—time, time intervals, voltage, current, power, phase, weight, length, stress, color, height, density, viscosity. Any of these physical quantities may be measured by a tube, and once they can be measured it is only a question of properly translating the measurements into control

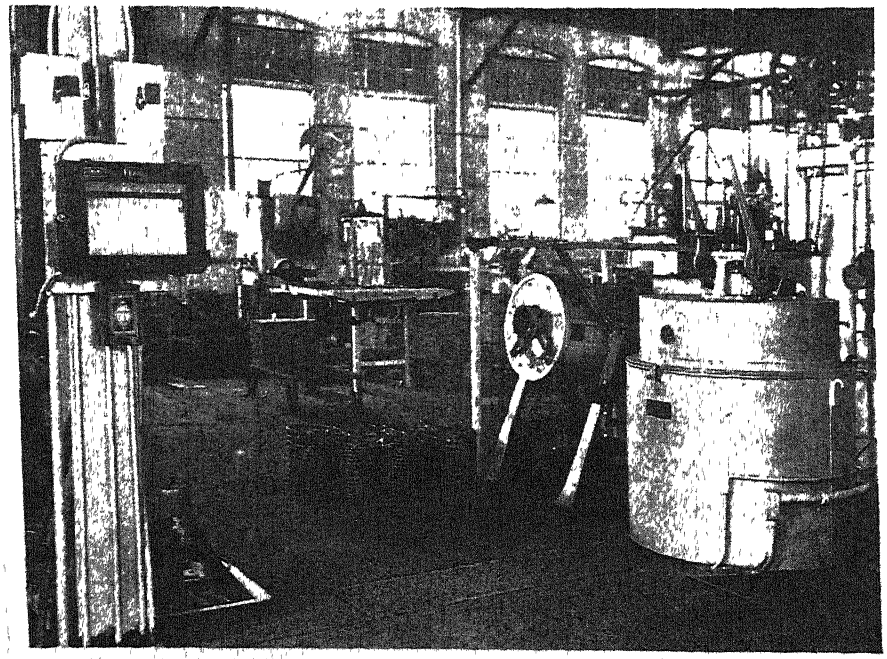
For example, if some mechanical device is to be kept on a straight and narrow path in spite of a strong tendency to stray from this path, two phototubes can be arranged so that if the device gets off the path to the right it reduces the illumination into the right-hand tube, and so that it shuts off light into the other tube if it goes off the path to the left. Now it is not difficult to make the right-hand tube control a motor so that it will rotate in a clockwise direction; or to make the left-hand tube force the motor to rotate in a counter-clockwise direction when the left-hand tube is obstructed The motor can be connected to the mechanical device. So long as the device stays on the path, which can be very narrow, both phototubes get illumination and current tends to flow through the motor in two directions, each half of the current exactly balancing the other half so that the motor does not rotate. But as soon as, say, the left-hand phototube is obscured, it passes current through to the motor, which gets busy and brings the object back to its proper position.

Holding a telescope on a distant star can be done in this way, and the imaginative reader can see many other applications in the activities we are now engaged in abroad There are literally dozens of uses for a set-up of electron tubes plus a split-field motor. The tubes need not be phototubes, but are used here only as an example. In this case, the unit is a "position" control and can be employed as a "follow-up" system.

ALL-OR-NOTHING—Tubes make excellent limit gages or limit switches A thyratron tube, for example, has an all-or-nothing characteristic. That is, if the voltage applied to its input circuit is insufficient to produce current output, no current flows, but if the voltage gets beyond this value, all the current the tube can handle will suddenly flow through it. On the other hand, the circuit can be arranged so that, as long as the voltage is high enough, no current flows, and as soon as the voltage drops below this value, current is initiated. By making the critical values of voltage for the under- and over-voltage device close together the actual voltage may be

Job to be done	Stimulus	Tube Type	Indicator or Device Controlled
Elevator control	Light change	Phototube	Relays and motors
Elevator control	Magnetic field change	Amplifier or oscillator	Relays and motors
Vibration control	Piezo-electric voltage crystal	Amplifier	Loud speaker or Recorder
Paper thickness control	Capacitance change	Oscillator	Power relays

Typical examples of control jobs done by electronics. Note that in each case there must be some stimulus, that this stimulus is translated into an electrical quantity, and that this quantity initiates the control function to be accomplished



Electron-tube control of a furnace. The TAG unit at the left regulates the pot type General Electric furnace, at right, in which the teeth of circular saws are hardened

kept quite accurately within close limits

To understand the simplicity of many electronic devices, consider the elementary job of counting boxes which look exactly alike but contain two different materials. The boxes travel on a moving belt but a separate count is to be made. If a red spot is painted on one type and a green spot on the other, two phototubes properly placed will "see" these spots as they go by. Now if a filter is placed over one phototube which will pass only red light, and if a filter which will pass only green light is placed over the other tube, the red-painted boxes will register only on the red-filtered phototube and the green boxes will be counted by the other.

But suppose the red boxes are to move off to another belt, say to the right, while the green-painted boxes are to move straight along. It is a simple matter to make the red-filtered phototube interpose in the path of the boxes a mechanical arm which forces the red boxes to leave the belt and go off in the new direction. The arm is removed when a green box comes along. Now this is not merely counting—it is controlling the direction or route of the boxes; it is a control job.

COMPLEX FOR ACCURACY—Of course, the complexity of the electronic system employed depends upon the accuracy or perfection with which the control is to operate, as well as upon the variety of the job to be done. Some systems can be simple and others naturally must be more complex. Often the tube apparatus is only a small part of the entire control system Sometimes a given equipment can exercise several degrees or even several kinds of control in sequence or simultaneously.

For example, an automatic arc welding machine may have its filler electrode fed to the arc by means of a small motor completely under electronic control Signals taken from arc voltage or other desirable circuit conditions are amplified and handed on to an electronic system which governs the rate at which the welding electrode is fed. Moreover, the same control has provisions for striking the arc by touching the electrode to the work, then quickly backing off or reversing until correct arc length is established.

One of the advantages of electronic devices is the fact that the tube equipment and the push button that puts it into action need not be near each other. Many varying quantities or functions or jobs can be accomplished by remote control. In fact, there is almost no control job that cannot be performed by some application of the science of electronics.

Amplifier: Low voltage to high voltage
Rectifier: A.C. to D.C.
Oscillator: D.C. to A C.
Inverter: D.C. to A.C.
Phototube: Light to electricity
Cathode-ray tube: Electricity to light

Electron tubes are of many types which may be grouped as shown, but the different jobs that can be done by any one group or combination of groups are many and varied

Electron tubes in this set-up automatically time the duration of the current used for resistance welding

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STATISTICS

Show Some of the Trends In Electronics

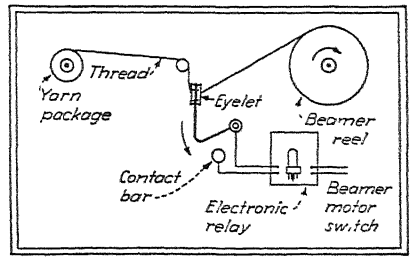
A FEW factual figures covering electronic progress are interesting as indicative of what is to come in this field. 25 billion kilowatt-hours of electrical energy flowed through electronic devices in 1943 6½ billion dollars represents the total war expenditures for electronics by end of 1943. 500 million dollars is the 3-year expenditure for electronic war apparatus, excluding radio. 1½ million kilowatts of electronic rectifiers have been installed by one company alone. 120 million dollars is the total expenditure for rectifier apparatus to date.

ELECTRONIC STOP

Controls Textile Machine When Thread Breaks

AN ELECTRONIC relay recently developed by General Electric stops all the motion in a textile machine the instant a thread breaks Just before the threads come to the beamer each thread passes through a hinged eyelet, called a drop switch. When the threads are wound on the beamer they are in tension and hold the drop switches in an open position When a thread breaks it is no longer in tension and the drop switch, its weight unsupported, drops to the metal bar.

The contact to the metal bar causes a minute current flow in the input circuit of the relay tube. This current, only a a few microamperes, is amplified by the tube which in turn operates a relay in the output circuit The relay then opens the coil circuit of the motor switch and stops the beamer machine.



Electronic textile machine control

CONNECTIONS CHECKED

By X Rays, Rejections Greatly Reduced

AN X-RAY unit now in use in a large industrial plant has helped reduce rejections, originally as high as 75 percent, to an average of 4 percent. The plant uses a Kelley-Koett X-ray unit for fluoroscopy and radiography to check soldered wire connections within a metal tube, 48 at a time. The cost of fluoroscoping is negligible and it requires no darkroom, films, or chemicals.

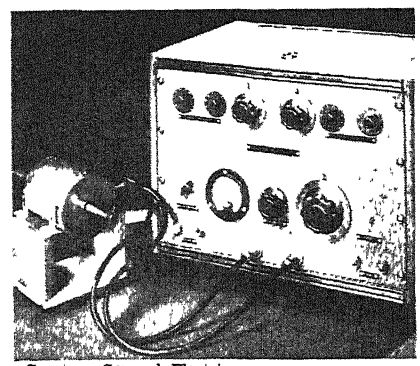
FLAW DETECTOR

Applied to Production of Metal Tubing

A NEW high-frequency electronic flaw detector permits production-line detection of longitudinal cracks and seams in non-magnetic metal tubing The instrument detects and locates imperfections one half inch long, ten mils wide, and one third of the wall thickness in depth, even though they do not appear on either surface.

The tubing to be tested is fed through coils arranged so that they surround it. After the circuit constants for the particular size of tubing being tested are set by means of selector switches located on the panel of a control unit, power is applied to the coils so that eddy currents are induced in the tubing. A flaw in the tubing causes changes in these eddy currents. An electronic circuit in the control unit detects these changes and energizes a signal relay, indicating the existence and location of the flaw.

The detector consists of a standard control unit, shown in the photograph, and a coil box which accommodates any one specific size of round, straight tubing of uniform outside diameter from one quarter to two inches, inclusive.



Courtesy General Electric

Flaw-detecting tube coil is at left

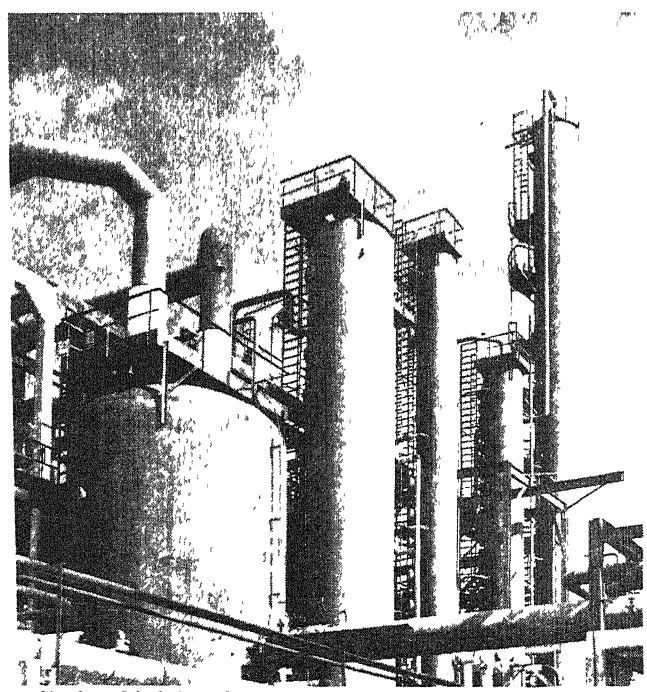
What About Synthetic Tires?

Synthetic Production Outstripped the Rise of Knowledge of Uses, but Something is Being Done About This. Competitive Prices Now Favorable to Synthetics. Politicians Do Not Expect to Protect the Huge Investment in the Synthetic Rubber Industry. Tire Life May Equal Car Life

If your tire treads are wearing thin and you think something should be done about it, you are dead right. And something is being done A veritable army of scientists and technologists work day and night on just that problem Synthetic tires are good now, but will be excellent After performing the astounding miracle of creating in little more than two years a totally new complex industry able to produce synthetic rubber at a rate faster than Americans have ever used the product of rubber trees, American enterprise and ingenuity are now busy with the next task That of making synthetics so good and so cheap that we shall never wish to return to Nature's rubber again. Just as production of the new compounds in quantity has been accomplished in an incredibly short time, so we may expect the second part of the problem to be solved with skill and dispatch.

Utilization of synthetic rubbers is still a problem because their production was accomplished too swiftly for methods of use to be developed simultaneously. Obviously, when the program of production in this country finally got under way, after the fall of Singapore had cut off supplies from the Far East, haste was vital. The new industry must produce in the shortest possible time, and its products must resemble rubber so closely that existing rubber machinery could be used with the least possible alteration to fabricate them into tires and 30,000 other useful items made of rubber. Speed was essential. Butadiene (pronounced bu-ta-dí-ene) must be derived from both petroleum and grain alcohol, and styrene produced from coal tar, in unprecedented quantities. Their combination, now known as GR-S (Government Rubber-Styrene), offered greatest promise for general utility, particularly in tires. Consequently, this was chosen to receive the greatest emphasis in the production program.

But GR-S is definitely not rubber; it merely bears a close resemblance to its prototype. On that hangs the problem of utilizing it. Such apparently unimportant details as differences in stickiness—technically known as "tack"—complicate the problem of the rubber fabricator Fundamental differences in the action of various additions to the mix to control the final properties of the product—its strength, its vulcanization, its resistance to wear, among others—require re-evaluation of every phase of rubber technology to bring out the best performance of the new material and adapt it to every-day uses.



Standard Oil photograph

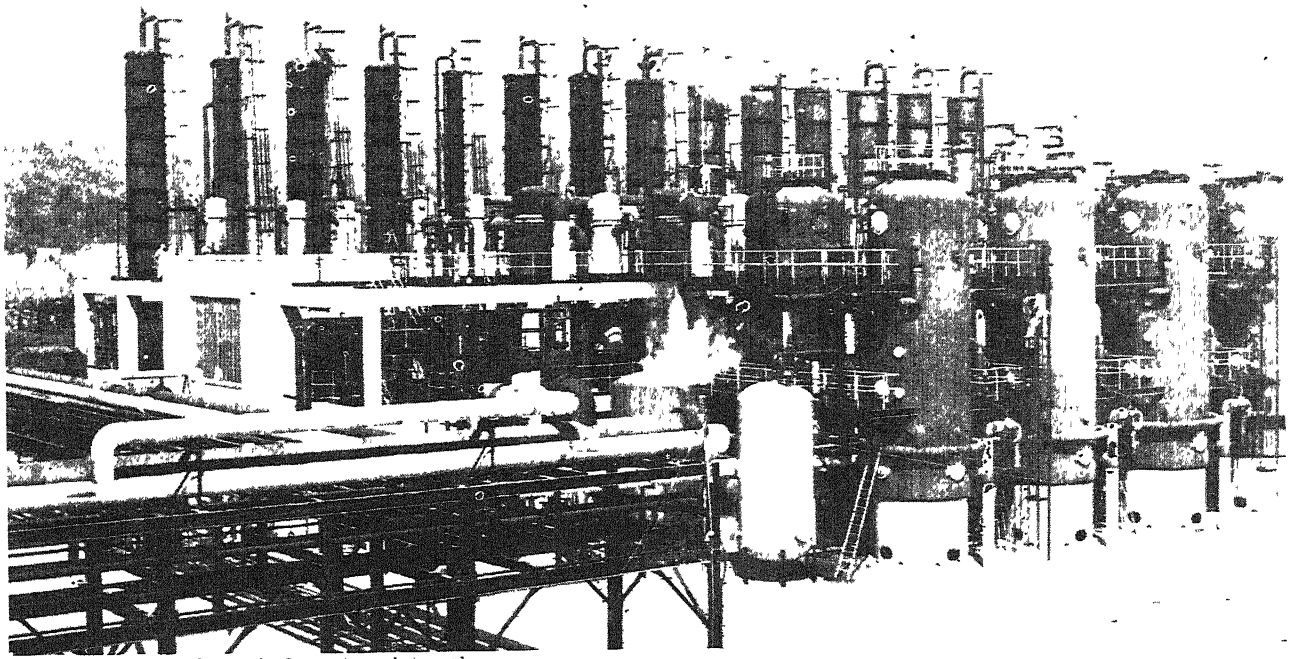
In these towers and reactors, man-made rubber gets its start with the processing of petroleum gas to obtain butadiene. This is combined with styrene to make GR-S synthetic rubber

Because synthetics resemble rubber closely, many expect them to duplicate it exactly. Unfortunately, that it is not true. But neither is it true that all good qualities reside in Nature's rubber and none in the man-made varieties. Rubber undergoes a subtle transformation when heated with sulfur and becomes a much more useful stuff. So do the synthetics. Colloidal carbon added to rubber before vulcanization increases its strength and resistance to wear. Synthetics are similarly improved Flexing rubber generates heat The synthetics treated in the same way generate more heat Rubber deteriorates through aging in air and sunlight Synthetics possess much greater natural immunity to aging. Both are benefited by additions of certain chemicals. Rubber deteriorates when soaked in water, while synthetics generally are practically unaffected Certain synthetics possess high resistance to oil and gasoline not shared by rubber Some synthetics, particularly GR-S, resist wear better than rubber does. While these statements are generally true of synthetics, the degree of difference varies considerably for the several kinds of synthetics.

Most important difference, from the point of view of tires, between rubber and GR-S is in the amount of heat generated under severe flexing, like that characteristic of balloon tires in use. Both materials are poor conductors of heat and both deteriorate rapidly when over-heated. Thus an important problem confronting tire builders is to find a way to get rid of the greater amount of heat formed within the synthetic tire in service Several possibilities suggest themselves: Thinning the tire sidewall, introducing heat-conducting substances into the side walls to carry the heat away, or, what may be far more important, changing the entire geometry and construction of the tire itself.

In other words, the technology of rubber, built up painstakingly over the century following Goodyear's original discovery of vulcanization, must be duplicated for synthetics but with no time in which to do it.

Rubber, itself, became useful by slow degrees. Tires, for example, were originally mere strips of rubber wound around a buggy wheel to replace its steel rim. Subsequently they acquired a pneumatic center. Each step in tire development, after that, was taken to adapt rubber better to the job of ab-



Carbide and Carbon Chemicals Corporation photograph

Butadiene, made from grain alcohol, is produced in this section of a government synthetic-rubber plant in West Virginia

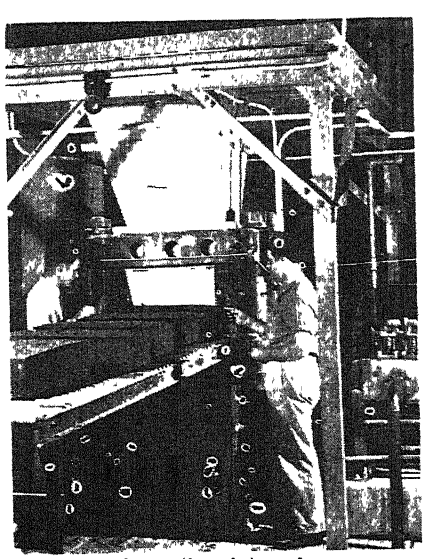
sorbing shocks from the uneven surface of the roadway Demountable tires were devised to allow for repairing punctures frequent in the early days of automobiling

But all of that must be re-examined and can be changed when peace releases industry for new tasks There is no reason to believe that the present tire and tube combination is by any means the best that can be devised for synthetics It must serve for the present, but tomorrow's tires need bear no particular resemblance to yesterday's The technique of bullet-proofing can be applied to banish all danger of punctures and thus any need for removing tires for repair Blowouts can be made a memory by utilizing in tire construction some of the super-strong fibers—stretched rayons, nylon, even glass and steel—to reinforce the tire carcass beyond fear of blowouts in operation Thus the necessity for removing tires from wheel centers can become obsolete, and the possibility of building tire and wheel center as a unit becomes practical Already the wearing qualities of tire treads made of synthetics equal or even surpass those of rubber, and it is easily within vision that tires having lives approaching that of the car itself can soon be made

SUPERIOR SYNTHETICS — Handicapping the realization of these possibilities now are More complete technology of synthetics for best possible results in tires, and, what may be equally important, restrictions on machines and tools which prevent rubber fabricators from completely revising or replacing such equipment of their plants as may be necessary to meet new needs For the time being, both of these handicaps prevent available synthetic tires from being as good as they can and soon will, be It can confidently be said that the time is not far distant when quality of product from synthetics will be actually superior to that from rubber

Political views on the future of American synthetic rubber production have already indicated that no special consideration for this industry can be expected after the war Official pronouncements on the subject from the present Washington administration suggest That natural rubber will be encouraged to come back at war's end, presumably to cheapen rubber products and to provide markets for plantation rubber, and that no measures are contemplated to protect the huge investment in this new industry and the insurance it affords against repetition of our present rubber troubles One might expect that preserving the new jobs for American workers created by the industry to be a vital factor, but this aspect of the problem seems to have been completely neglected Indeed the whole situation is far from simple

Since price looms large in political thinking, it is worth while to point out here that the present price of GR-S synthetic is already a little lower than the average of several pre-war years' prices of plantation rubber Furthermore, the trend of this price, as of all other chemical prices, is definitely downward Depending upon the length of the Pacific war and the time required after the peace to reestablish our rubber supplies from plantations in Malaya, competition by synthetic production here may even force prices to levels unprofitably low for plantation operators

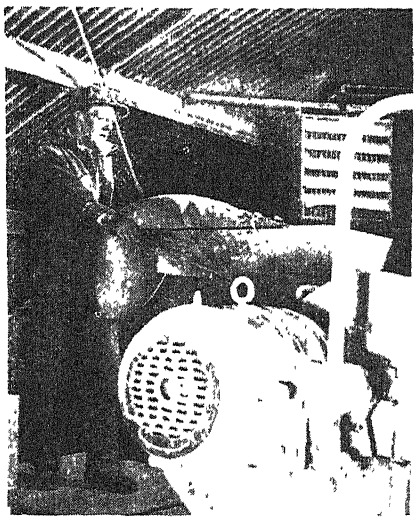


Copolymer Corporation photograph

Blocks of processed synthetic rubber emerging from a power baling press

TIRE PRICES—Rubber cost forms only a minor fraction of the cost of tires to consumers, since fabrication, other ingredients, and labor make up by far the greater share of the selling price of the finished tire Thus doubling the price of rubber may necessitate a change of only a few percent in tire cost

Often overlooked in planning for the future of rubber, but definitely vital, is the condition of the plantations at a future date when their output will again become available to us Just what steps are being taken by the Japanese conquerors to preserve the productivity of rubber plantations is now hidden behind the enemy's censorship. Neglect can quickly damage rubber plantings beyond repair Indeed, even the short period since the Japanese invasion of the rubber producing areas is ample for serious damage to have been done



New England Alcohol Company photograph

Grinding grains in an alcohol plant, a step toward synthetic rubber making

It is even probable that the immense stores of crude rubber acquired by the invaders exceeded their needs to an extent that would discourage them from sparing men to care for the trees themselves.

Enemies of rubber trees are legion, but the two principal ones likely to gain ascendency through neglect, are Several types of blights and insects which require frequent spraying of the trees for control; and invasion of cultivated plantation lands by the jungle. The first destroy the trees themselves, and encroachment of jungle growth on cultivated lands would prevent access to such trees as remained uninjured otherwise. These destructive agencies are seriously to be feared because the rubber trees (*Hevea brasiliensis*) require seven to ten years from planting to grow to productive maturity. Thus, any plantation which has lost its ability to produce through neglect cannot be immediately rehabilitated. Newly planted trees would require years to reach productivity, and meanwhile our synthetic industry would have time to mature in its own right before it faced the necessity of defending itself against the foreign natural product.

Present efforts to promote the growing of rubber trees in more accessible areas must necessarily continue, lest even at peace we find the natural product impossible to obtain. At the present time, fabricators still need a certain amount of natural rubber to include in their compounds with synthetics to yield best results. This may not always be true but, meanwhile, prudence requires that we continue to plan on this basis.

While the foregoing discussion deals principally with pneumatic tires and with GR-S synthetic, applications to rubber's former uses of this and a wide variety of other synthetics are succeeding much more easily and completely. For example, the vinyl resins are proving valuable in electrical insulation; polyvinyl acetals make excellent "rubberized" sheetings for moisture and rain resistance; hose for water, steam, oil, and a variety of solvents is better when made of a number of synthetics than when made of rubber; and so with practically the whole list of rubber's applications Most of these markets seem likely to be permanently lost to rubber because of the definitely superior performance of synthetics and quite regardless of their relative prices All these miscellaneous applications of rubber have normally consumed barely 20 percent of our imports of the elastic, while tires account for the remaining 80 percent.

Obviously the final solution of the problems of synthetic tires is a matter of general concern, but it is already well on the way

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PENICILLIN PRODUCTION

Approaches the Synthesis Stage

PRODUCTION of penicillin is increasing so rapidly that, by late spring of the present year, supplies are expected to reach a point where the vital drug will be available to the civilian medical profession generally. Recent progress includes development of methods of growing the drug-producing mold in large vessels instead of laboratory bottles as heretofore and the preparation of a pure crystalline sodium salt of penicillin which has been proved to be its active principle. This isolation of the drug in pure form is considered the most important step toward its ultimate chemical synthesis, which will avoid the need for cultivating mold to produce it

SOAP IN LUBRICANTS

Put to Many Uses in Industry

USED AS a lubricant, soap is assisting in the production of shell and cartridge cases, barbed wire, cables, springs, and cold-drawn bars, wires, and steel blanks of many kinds. In fact, most of the metal that is cold-fabricated for war utilizes soap at some stage in its manufacture, according to Roscoe C. Edlund, Manager, Association of American Soap and Glycerine Producers, Inc.

Practically no metal object is produced without being drilled, turned on a lathe, or drawn. In each of these operations, a lubricant is necessary to reduce friction, remove heat, prevent corrosion, and produce a smooth, accurate finish. In drawing wire, there is a friction of approximately 18,000 to 30,000 pounds per square inch within the die, which must be reduced by various methods of lubrication.

Soap is almost universally used for this purpose because it is clean, easy to handle, concentrated, and more easily adaptable to a wide variety of conditions. Dry drawing calls for powdered soap; wet drawing uses flake and powdered soaps as well as soft soaps. These are used in conjunction with other substances, depending upon local practices and conditions.

In dry drawing, the powdered soap is made generally from a tallow, although, when available, palm oil and a combination of palm oil and tallow are used In wet drawing the wire and die are either submerged under a soap solution in water or the soap solution drips over the die and wire while drawing The purpose is to reduce the friction between the moving wire and the die surface, to lessen the force required to pull the wire through, to reduce the wear on the die, and to give a smoother finish.

Soap coating eliminates the need for copper plating in the manufacture of 37mm cartridge cases, now made by cold drawing from steel blanks.

Soap is used extensively in the preparation of lubricants for drawing copper and brass tubes and wire, also of cups in the production of shell cases for ammunition.

Soap is a vital component of a large number of new greases with which technicians are meeting new production problems. The addition of soap produces a grease which will not leak away from points of friction and which adheres to rotating surfaces better than straight oil These new lubricants are especially useful in pumps and carburetor valves that come in contact with gasoline which quickly dissolves ordinary greases.

Soap is also used in cutting oils which have been developed to meet the exacting requirements of many kinds of high-speed war production. When used in such cutting oils the soap acts as an emulsifying and stabilizing agent It improves the stability of the oil emulsion and increases its film strength.

A certain proportion of soap added to airplane grease lubricants makes them more resistant to extreme cold and to sudden changes in temperature

GLASS WASHERS

Help Signal Corps Develop New Lip Microphone

TINY WASHERS made of glass fibers bonded together and pressed into a wafer-like mat have helped the United States Signal Corps solve one of the many problems involved in developing a noise-canceling lip microphone now used by the Marine Corps.

The Fiberglas washers were adopted after the Signal Corps, working with Electro-Voice Manufacturing Company, had tried out numerous materials in a search for one that would remain resilient and exert even pressure on the metal diaphragm of the "mike" under combat conditions such as those encountered in the moisture-sodden jungles of the South Seas.

The new microphone prevents the thunderous noise inside a tank; or the rattle of machine-gun fire, from interfering with clear transmission of speech As its name implies, it is worn on the upper lip, leaving the hands free. It is part of the radio equipment which enables scouting parties or armored vehicles to maintain communication with each other and headquarters.

The wafer-like mats from which the washers are made are manufactured by Owens-Corning Fiberglas Corporation

Materials Must Move

Costs Go Down, Production Goes Up, When Materials-Handling Problems are Correctly Solved. Management Thinking is Changing and is Placing Emphasis on this Vital Phase of Industry. Exact Control Achieved While Maintaining Flexibility and Adaptability of Equipment

WHEN PEARL HARBOR so rudely interrupted United States peace-time factory management, one subject had long been first on the engineering docket. It was the fact that materials handling never accounted for less than 50 percent of all production costs and often made up 80 percent or more. Greater savings, and often greater increases in out-put, could be made by solving materials-handling problems than by any other "short-cut."

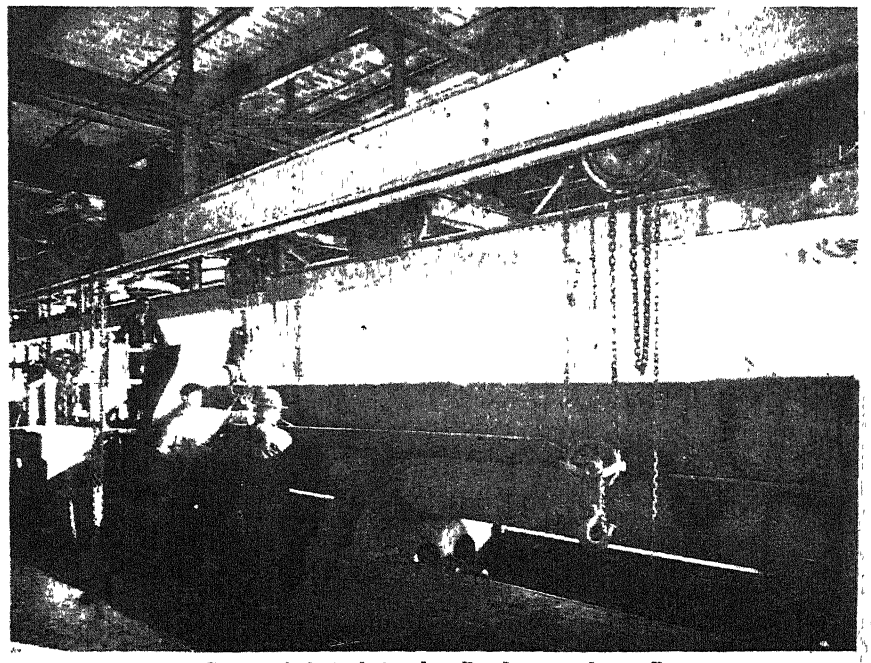
War-production thinking paid less attention to costs than to quantities and speeds, but from the first moment when factories began expanding to war time proportions, one fact was clear: This was to be a materials-handling war. Beginning with the instant when the scoop of a power shovel lifted iron ore from the ground and ending with the dropping of the resultant steel in a block-buster on Berlin, materials-handling skill would decide who got "thar fustest with the mostest." Materials had to move or machines and manpower would be useless.

Large companies already had shown the way. Bendix Aviation, with one good factory available, had erected a new one, largely because a different size and shape of building was needed for adequate handling of materials. Westinghouse had some 27 miles of conveyors in just one plant Bell Aircraft had built a special factory so that airplanes could be towed down the assembly lines by hooks fastened to chains which ran below the floor level And when Ford Motors built its Willow Run plant largely because the mazes of materials-handling equipment in automobile shops could not be adapted to aircraft, and General Motors and others whipped up new buildings for the same reason, the great change in management thinking became clear. Henceforth machining and other production methods were to be adapted to materials handling at least as often as materials handling was correlated with the other functions.

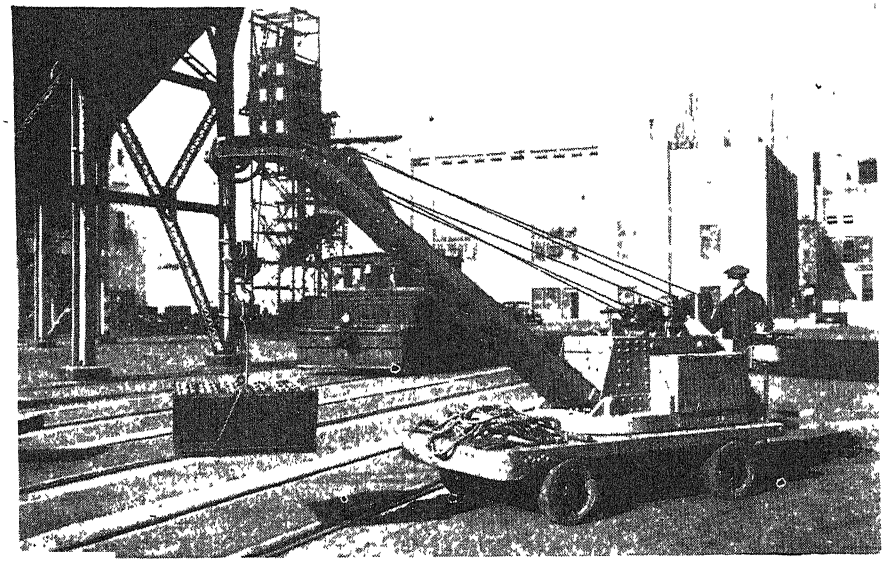
The ideal of the perfect factory built around the perfect materials handling system is an old one. Before 1930 a factory had been built by the A. O. Smith Corporation to turn out automobile chassis frames without human hands touching them. Steel went into one end of the building, was cut, formed, shaped, and welded, traveling several hundred yards through the successive machines and emerged all painted and ready to be mounted in automobiles, all without a human being in the building; although, later on, a small crew of maintenance men had to be kept in the plant. The Gillette Safety Razor Company fed Swedish strip steel into one end of a long line of machines and had it emerge as packaged razor blades, with only a few men to keep the machines in adjustment.

PRODUCTION HEADACHES—But the war brought new problems. First was the insistence of the armed forces that they be able to change almost anything upon a minute's notice When the bazooka and other rocket guns lessened the utility of tanks or one type of fighting plane made another obsolete, the war factories had to change over to something new at once. Perfect set-ups based upon the expectation of years of making just one thing in just one way were out. Second, materials supplies were tighter; there could be fewer "pools" of semi-finished parts and of supplies held at points along the production lines so that a process would not be stopped if the flow of materials to it were interrupted; that flow had to be interruption-proof. Third, scrap from every process had to be kept segregated as never before; scrap handling no longer was a question of separating the materials which could be sold at a profit and letting the rest get mixed, but became one of protecting all waste as strategic and critical materials. Yet in spite of these troubles—and plenty more—materials handling had to keep on performing its function of reducing the man hours per thousand parts produced and of saving floor space.

The effect of the abrupt changeovers of factories was to require everything to be adaptable to changing conditions In nearly every big factory today, the moving of machines from one position in the production line to another is so common as to be a specialized function of the materials-handling department. In one big factory, machine bases are painted with identifying markings to show the methods to be used in moving them; those having green stripes to be lifted by overhead cranes, white stripes indicating that the machine is neither topheavy nor delicate and may be towed by tractor either on its own base or after mounting on skids, and



Gangs of chain hoists handle sheet steel at rolls



Electric crane, yard locomotive, elevator, silo, all handle materials

red stripes warning that jacks and rollers are to be used and the moving supervised by the foreman of the department which uses the machine

PORTABILITY THE KEY — Some lightweight equipment such as drill presses, grinders, welders, and small furnaces, is kept permanently mounted on steel skids so that it may be moved at will by lift trucks Materials-handling equipment also is kept fully portable or semiportable, gravity roller lines being in sections which can be disconnected, and often being mounted on frames supported by steel wheels so that it can be rolled from position to position; belt conveyors being in sections which feed to each other rather than the longest practical single lengths being installed, and even the overhead tramrail systems being supported by easily moveable special pillars instead of permanently suspended from the ceiling

Scrap segregation has posed peculiar problems The trend toward equipping each machine with its own vacuum evacuator to suck up the chips and dusts as fast as produced and deposit them in a chamber right at the machine instead of using one long vacuum line with ports at many machines, is promoted by the fact that the individual chambers can be dumped into special wheeled materials-handling bins and the scrap of various alloys thus kept from becoming mixed In extreme cases, such as machines which cut tungsten alloys, the cutting oil from the sumps is pumped into individual portable tanks rather than into a single "dirty oil collector," the segregated oil being cleaned in special settling tanks and centrifugals.

A manufacturer of steam turbines has placed all producers of metal scrap, except the very heaviest machines, on galleries along the main production line Stock rooms running along the outer edges of these galleries feed materials to the machines and receive the scrap from the machines they feed. Thus the same men who keep new materials separated also keep the scrap of those materials segregated. Materials go to the lines on the upper decks of roller conveyors; the scrap comes back in tote boxes and bins on the lower decks of the same conveyors and is carried at floor level to the outer wall where it is stored until collected

A brass and bronze castings plant long has had a system by which molding sand is carried on conveyor belts spaced at intervals across the foundry floor, these belts being reversed to take spent sand back to sifters and thence to a main conveyor belt leading to the sand mixing and tempering equipment when the flasks are being emptied Several different alloys may be handled at one pouring In the pre-war days the system could be run easily, since a little mixing of the bits of metal remaining in the spent sand and caught at the sifters resulted only in "random" scrap which could be melted for castings in which exact alloying is not too important But with scrap segregation so important in war-time and the government demanding that every ounce of the precious copper alloys be accounted for, the materials-handling department had to designate some belts to handle definite alloys and to regulate the use of others so that only one alloy is on a belt at a time.

The lack of pools of materials to compensate for failures of materials-handling systems to keep up with the lines, has been solved by two methods One of these is to spot stock rooms about the plants rather than to hold all materials in single big rooms, the small stock room can be close to the point of use of the supplies and tools it holds and the haul from it to an emergency point is short and accordingly quick The other method is to use more electric lift trucks and other completely portable materials-handling devices

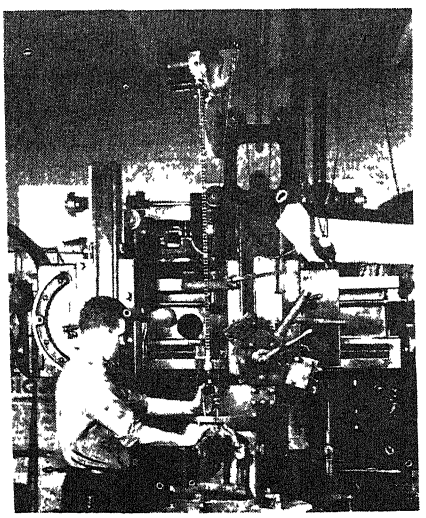
Use of trailers, to be towed by powered lift trucks or by tractors, is increasing materials-handling flexibility As ordinarily used, long trains of these trailers are towed down the factory aisles, individual trailers being disconnected and left where the goods they carry are needed. A foreman, seeing that a shortage of a material is likely to occur in his department, simply picks up the shop telehpone and calls the materials-handling department which then arranges to have an extra trailer or so hooked on to the next train going his way

When trailer systems are well worked out, constantly moving chains often are substituted for the tractors In original designs of these systems the chains were run overhead, but modern ones are more likely to run them in channels just below the floor level A trailer may be loaded at a dispatching station and hooked to the chain, to be towed to its destination and unhooked

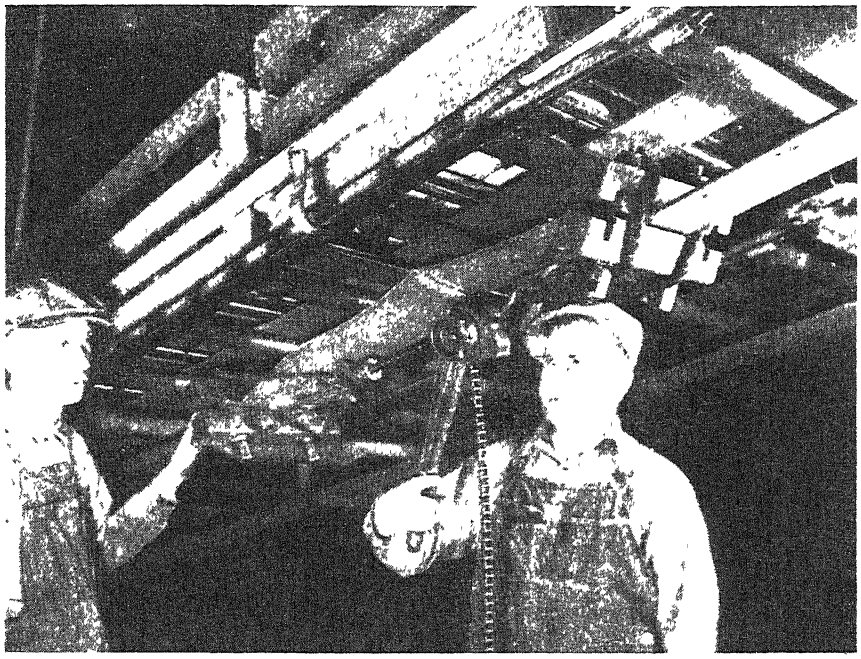
BOXES STACKED—The use of stackable boxes or bins increases lift truck or trailer flexibility In one factory as many as six heavily loaded steel boxes are stacked on a single trailer and taken to the head of a production line The trailer is then unhooked from the tractor train and towed by hand from machine to machine, each successive box being lifted off by chain hoist and placed by the machine operator who needs it Emptied boxes are placed on a gravity roller conveyor, which takes them back to the despatch station. The emptied trailer, if not needed for conveying materials away from the department, is turned upside down, mounted on an empty box on the gravity line, and so carried back to the reloading point.

A feature of modern materials handling is the increased use of locked or sealed containers to insure exact count and control of quantities, protect against theft and sabotage, maintain exact temperatures, insure cleanliness, and the like Highly accurate parts are delivered in packages which are wire strapped and sealed by the inspectors; no faulty parts can be slipped on down the production line by machine operators who wish to avoid the losses of incentive bonus earnings entailed by doing work which would not pass inspection

WHERE WEIGHT COUNTS—More scales are used in materials handling than ever before Scales are an old story on everything from tramrail conveyors to lift trucks and trailers when handling chemicals which must be mixed accurately Now they are found also on equipment which handles tools and metal parts One large machine shop



Every large machine in a modern machine shop has its service hoist



Hooking up a live roller conveyor drive belt

has the exact weight of every important jig, die, set of micrometers, and so on, written down at the place where the device is carried, when issuing or receiving one of these tools the stock clerk weighs it and, if the weight does not correspond with the stock tag he finds out what is wrong; the management estimates that this system saves up to 1000 machine hours per month of time that formerly was wasted by errors in tool deliveries Exact weighings of forgings tell foremen how much stock must be removed in machining them lead to closer estimates of machining time and better control of production schedules Weighing of finished parts gives a quick check on machine-by-machine output permits all production to be kept up to levels which could not be attained when output was known only by counting the gross quantities which batteries of machines delivered to the stock room.

Materials handling is achieving more exact control of everything while maintaining the kind of flexibility and adaptability of equipment which ordinarily would lead to inexactness. It is obtaining this control as a result of war pressure accompanied by many headaches But this is not anything which will die out on Victory Day. Rather, the development will be carried further when equipment is easier to get. The materials-handling war will end in the most skilful materials-handling era of all time

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COPPER SAVED

Power Gained by Use of High-Voltage Lines

AN ELECTRICAL distribution method, originally designed to use less copper and less costly transforming equipment, is saving the power costs which voltage drops can cause, and is permitting greater flexibility in moving equipment about the plant.

The method is to run high-voltage lines, say 2200 volts, direct to small transformers at the distribution panels throughout the plant instead of having a single large transformer out in the open and running low voltage lines from it.

The high-voltage transmission line needs less copper for the same power rating than the lower voltage, and the substations with their switchgear also cost less. In one direct comparison, cost of the old type outdoor transformer, plus switchgear, secondary switchgear, and cables, was estimated at $57,000, while cost of the indoor system with its substations was about $45,000, a clear saving of some $12,000 Most of this saving, of course, represented copper and other strategic materials.

Biggest gain of all is that, although it has moved machines, changed production layouts at will, employed green labor which would misuse power-driven equipment, and done all the other undesirable things which are unavoidable under war production conditions, the plant has yet to experience its first voltage-drop troubles

COLOR CODES

Serve in Minor but Important Ways

A LARGE user of electric motors mixes a little coloring matter with the insulation varnish used when overhauling these motors. A different color is used each year. As a result, the electrician can tell at a glance the year during which any motor had its last overhaul This method causes no trouble whatever, and short cuts some of the elaborate record-keeping which is common to all electrical maintenance departments.

A plastics plant, having trouble with unskilled labor installing special valves backward so the water would enter the discharge instead of the intake ends, painted the intake ends green and the discharge ends red, put small arrows on pipes to show the direction of flow

An aviation materials plant uses an egg-shell white paint on the parts of machines, or on whole machines, which are most easily damaged by improper use of wrenches, by being bumped by materials handling trucks, and the like If one of these white areas is marred or soiled in any way an immediate investigation is made, the foreman being held responsible Damage to the housings of highly accurate bearings, and so on, is at an all-time low

FROM THE OFFICE

Comes Equipment that Aids Factory Workers

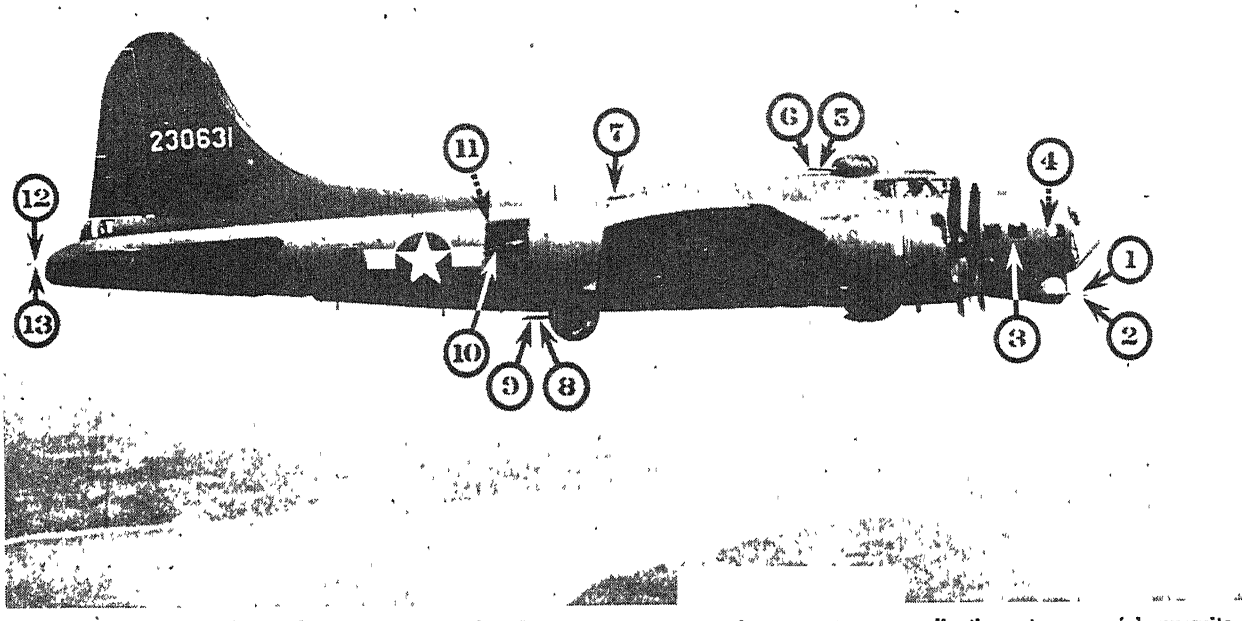
MANY A factory manager, learning for the first time how to get along with women employees, has gone to that veteran in the art, the office manager, to learn the tricks that work with stenographers.

One device taken straight from the office to the shop is the posture chair Women keep more alert, do better work, and have higher output in the tired end-of-shift hours, if given chairs which encourage healthful posture

Fact is, no woman wants any part of a job that will leave her at all mishapen A man does not mind if the use of his muscles causes him to bulge in a few of the wrong places, he is likely to regard shoulders permanently stooped from leaning over a lathe as a natural mark of a machinist's calling But his gal co-worker likes to come off the job better looking than when she went on.

Production managers first paid attention to these points as necesssary parts of personnel recruiting programs, but now regard them highly as direct promoters of efficiency. Posture corrective devices will out-last the war.

Posture is important



Gun-fire control on the weapons of the Flying Fortress may have post-war applications to peaceful pursuits

AVIATION

Conducted by ALEXANDER KLEMIN

Aviation's Hot-House

Civil Aviation of Tomorrow Will Inherit a Rich Legacy of Important Advances from the Forced-Draught Military Researches of Today. Giant Planes with New Landing Gears, Flying Wings and Tail-First Planes, Crewless Gliders, and Rocket Planes are Conservative Possibilities

It is a mistaken notion that supremacy in the air can be attained by mere quantity production of aircraft and the training of great numbers of airmen. Certainly great numbers of both planes and men are needed, but the freezing of military airplane designs to secure maximum production is fatal. Some recent remarks of J. Carlon Ward, Jr., President of Fairchild Engine and Airplane Corporation, will clarify this statement. Mr. Ward, after an inspection trip to England, believes that the Nazis are losing the war largely because the Army, Navy, and aviation industries of the United States and Great Britain adopted the principle of day-to-day development and improvement of aerial combat craft to meet all types of aerial warfare. On the other hand, Germany approached the aviation problem with the idea that designs could be frozen and that their designs, carefully developed in the years before the war, would suit the everchanging progress of the war. Therein was made a fatal error.

Moreover, it is not only on the airplane itself that the two English-speaking countries have concentrated their efforts. They have fostered research in all of the thousand and one instruments and accessories which go to make up the coordinated whole of military aeronautics.

Many of the multiple advances now being made in military aeronautics will undoubtedly redound to the benefit of post-war civil aviation. The airplane itself comes first, of course. Details of many new designs are rightly shrouded in secrecy, but hints come from the highest authorities and are freely released to the press.

Thus General H. H. Arnold, Commanding General of the Army Air Forces, speaks guardedly of the B-29. Writing in *Army Ordnance*, the General says "If you will glance into the near future you can see a very different picture than the one of today. The bombers will dwarf our present Flying Fortresses. They will carry half a carload of bombs across the Atlantic and fly home without a stop. The bomber's skin will have numerous blisters which in reality will be multiple-gun power turrets controllable from sighting stations." This super-bomber, the B-29, while it will not in any way slacken the production of the B-17 Flying Fortress and the B-24 Liberator, will outrank them because it will have a far greater effective range, will fly faster, will carry a far heavier bomb-load, and will employ far more powerful engines.

GIANT PLANES COMING—The B-29 will be received in combat areas with immense satisfaction, since it will combine the bombing power of the giant British machines with greater speed and gunfire. But the implications of the B-29 to post-war civil aviation will be many For transport aviation to be commercially profitable, to carry a really effective percentage of payload, we must use very large airplanes with as few and as large power units as possible The B-29 itself may ultimately be converted to commercial uses, but its design, development, and service testing have already taught us how to build giants of long range and carrying capacity. Engines have grown immensely in power, but when the Wright engine goes above 2000 horsepower, special difficulties in cooling appear. The development of the B-29 has taught us how to take the bugs out of these huge power units. Again, the design of Hamilton-Standard controllable-pitch propellers is no mean task; the B-29 provides a proving ground for large propeller design.

The B-29 super-bomber is stated to be but one of many military types to appear shortly on the scene, and Wright Field, the experimental field of the Army Air Forces Materiel Command is sponsoring or fostering them all. Details cannot be disclosed, but announce-

ments have been made of a "flying wing" and of a "tail-first plane." Neither idea is new, but if Wright Field and the industry succeed in perfecting the flying wing, benefits may accrue for post-war flying Since with the flying wing the fuselage is eliminated, there will be lower first cost and greater efficiency. For cargo carrying, the flying wing should have huge volumetric capacity and also permit rapid loading and unloading.

TAIL FIRST—In the tail-first plane, announced from Wright Field recently, the horizontal tail surfaces are placed at the nose of the fuselage, while the passengers are seated quite far back from the nose Therein lie two elements of safety The horizontal surfaces placed ahead and at a larger angle of incidence than the main wings, stall first and lose their lift first Hence the machine noses down well before a dangerous stalling of the main wings can follow, and recovery is aided

While the advent of the B-29 will make the Flying Fortress merely a medium bomber, it should not be thought that the Fortress is itself standing still. Emphasis must be placed on the great fire-power of the Boeing B-17 G which now carries thirteen 50-caliber machine guns as shown in the picture on the opposite page Guns One and Two, located in the new and deadly chin turret, and Guns Three and Four, are used by bombardier and navigator to ward off frontal attack Guns Five and Six are operated by the first engineer in the power turret, for frontal, lateral, and rear attacks. Gun Seven, a top gun located midway in the fuselage, is operated by the first radio operator against enemies from above Guns Eight and Nine are used by the second radio operator in the ball turret against attacks from below. Ten and Eleven, in the waist position, are operated by the second engineer and first radio operator for lateral attacks Twelve and Thirteen are used by the photographer and tail gunner to ward off attacks from the rear. All these guns can be worked independently or simultaneously Electric or hydraulic control can be employed and it is perfectly certain that at least some of the methods developed in gun-fire control will be applied post-war in actuating control surfaces, landing gear, and the like.

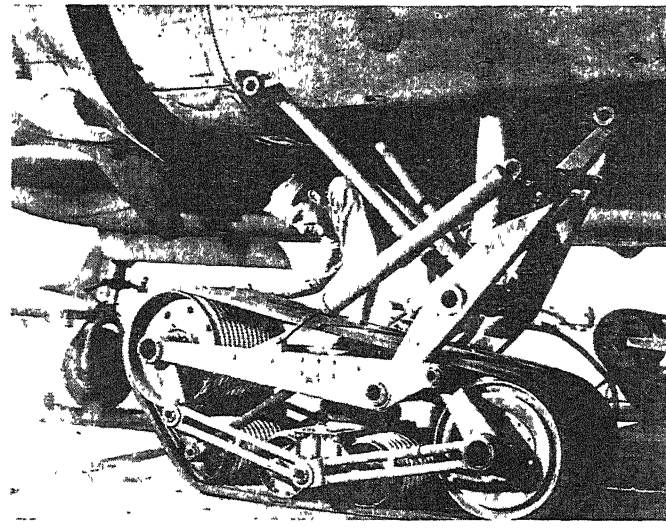
Perhaps even more important is the development of the new Sperry automatic gun sight—a mechanical "brain" housed in a little black box. With the new sight, the gunner seems to aim directly at his target, but the mechanical brain makes the necessary allowances for the speed of the plane, the speed of the enemy, the wind, and a number of other factors. The result is that the guesswork is now taken out of aerial gunnery by the computing sight which, no doubt, takes advantage of the principles of short-wave radio and of complicated mechanically integrating mechanisms Such a mechanical brain should certainly prove helpful in aerial navigation after the war and certainly has possibilities in other industries. It is not difficult to imagine a whole series of intricate chemical or metallurgical processes controlled by an appliance of this sort.

While gun-control methods have significance for civil aviation, the same cannot be said for the weapons themselves—except for the glider-rocket. A rocket-propelled glider, carrying a bomb or bombs, launched from a parent aircraft and steered to the target by remote control, is a close approach to the winged bomb or winged torpedo and has decided peace-time possibilities The use of towed glider trains is frequently and seriously discussed for air-transport purposes; the commercial possibilities of such glider trains would be much greater if the gliders themselves were crewless. If it is possible to control a glider as a species of flying torpedo, why could not gliders be released from the air train and landed at a field without the use of a pilot? Expense of operation would thus be appreciably reduced.

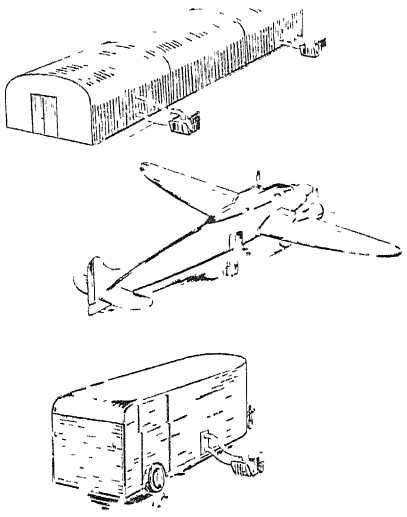
The Germans are said to be using rocket motors to take heavily loaded Dornier bombers off the ground; the British are launching their Catafighter planes from the decks of merchant ships with rocket power. While nothing as yet foreshadows the application of rockets in commercial aviation, there has come intense interest in rocket research along a number of different lines. These researches, not of conclusive value at the moment, may ultimately enable heavily loaded land craft to fly across the Atlantic with real payloads, and commercial aircraft of novel types to fly at great altitudes and fantastically high speeds.

Large and heavy airplanes—the larger the better—mean heavy and concentrated loads. Can even the best airports support the loads involved? Under the spur of military necessity and the use of rough terrain in combat areas, there has been developed by co-operation of Hub Industries and the A.A.F., a track landing gear such as that shown in one of our photographs. This gear employs principles somewhat similar to those used on tanks. The belt is tensioned so that it acts as a shock-absorbing medium, and Firestone Air Springs, with a levered suspension of the whole track mechanism, constitute an effective unit. With the ever increasing weight of modern aircraft, contact pressure on landing becomes so great as to be impractical. The track landing gear appears to

Main fuselage sections of Flying Fortresses advancing on the production line



Track landing gear for giant planes will replace wheels, reducing heavy concentrated loads on airport landing strips



Mobile air conditioner for airplane cabins can also be applied to jobs of reducing temperature and humidity in buildings, trucks, and the like

be one useful expedient to meet the difficulty.

In still another derivative of war-time aviation lies an introduction to the comfortization of the passenger cabin As Consolidated's *Plane Talk* has it "A big bomber today is not only an elaborate fighting machine, it is also a hotel, prepared to feed, sleep, and otherwise attend to the personal necessities of a crew of from 6 to 12 men—and perhaps a few passengers—for a day and a night at a time. For instance, it houses an auxiliary power plant to supply electricity to operate lights, radio, instruments, the inter-communicating telephone system, power turrets, and battery chargers. It also has a heating and ventilating system"

There could be no better training for the design of an airliner than taking care of these complexities. Moreover, the necessities of the armed forces constantly bring out new devices directed to some aspect of comfortization. Passengers on the airlines have noticed in the summertime that, while the planes are thoroughly comfortable in flight when cool air is drawn in by the ventilating system, their interiors become intolerably hot when they are standing still in the hot sun In combat areas it has been found that efficiency of mechanics, the development of aerial photographs, communications, care of sick men, all suffer under such conditions Accordingly, the Carrier Corporation has developed for the A A F. a light-weight mobile cooling and dehumidifying unit which can be wheeled up to the plane to deliver conditioned air through canvas ducts

NAVIGATION AIDS—The automatic pilot has deservedly earned a great reputation for itself. But there has always been the feeling that it would not quite do the job in very rough weather, that pilots then had to cut out the automatic pilot and trust to their individual skill. Now Wright Field has permitted the announcement to be made of a new electronically controlled automatic pilot developed by the Minneapolis-Honeywell Company The new pilot is said to take over completely the duties of the pilot on bombing runs, to hold the plane on a designated course without wavering The sensitivity of the electronic mechanism is such that it returns the plane almost immediately to its course despite cross currents, wind variations, and air blasts from exploding anti-aircraft shells. The possibilities of such an automatic pilot for commercial aviation are obvious.

Another aspect of aviation which has been immeasurably developed by the war is production, tooling, and manufacturing capacity, which have advanced to a degree which would not have been believed possible a year or two ago This means that when civil aviation once more gets under way, it will be able to count on considerably reduced cost of the airframe. Nothing could be more encouraging in this regard than the photograph of the main fuselage sections of the Boeing Flying Fortress advancing steadily in production lines As the long lines of bomber bodies pass through this section of the factory, they are fitted with complete installations Next they are moved forward by great cranes, where they are joined to wings, tail sections, and engines.

In this brief review it is not possible to touch upon a number of important phases of aviation such as fuels, the aircraft engine, and new materials. But surely enough has been said to indicate that in the hot-house temperature of total warfare, progress in aviation is rapid and multifarious From a technological point of view the post-war outlook for commercial aviation is bright indeed

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TOOL GRINDING

Automatic Process Reduces Metal Loss, Extends Tool Life

A PROCESS for grinding machine tools that promises to be of the greatest importance to American industry has been developed by Wright Aeronautical Corporation. Very little high-grade tool steel is lost during actual cutting operations, the real loss comes during the grinding necessary to sharpen the tools after they become dulled by use. Besides the loss of valuable strategic material, time is lost in the usual manual grinding.

Under the new process, special fixtures hold the cutting tools for automatic grinding, 18 at a time Additional fixtures hold the tools one at a time for a slight final grind on a very fine stone; the last operation is ultra-fine polishing. Under the microscope the edge of a hand-ground tool appears as a saw-tooth profile. In use, an uneven stream of the metal being machined is forced through the saw-tooth crevices, with local concentration of high stress and high heat. Hence the tool edge has to be reground frequently.

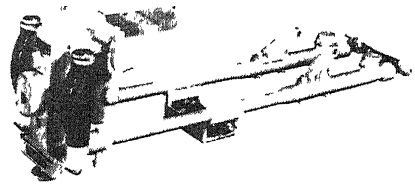
When the edge is precision ground and almost perfect, clean and straight under the microscope, these difficulties disappear. The result is that tool life is extended to a remarkable degree and less metal is lost over a given period of time. Where it was possible to cut 13 gears per grind with one type of hand-ground tool, it is now possible to cut 200 to 500 of the same gears with a machine-ground tool. Another tool had to be re-ground after each cut on one of the larger parts of a Cyclone engine Precision ground, the same tool now machines 28 forgings of the same part before regrinding is necessary Obviously, this new technique will be equally as valuable to other industries as to aviation and it is understood that full details are being released for use by other manufacturers and tool users

Aviation has benefitted greatly by help derived from other industries, now in many ways it is returning such benefits

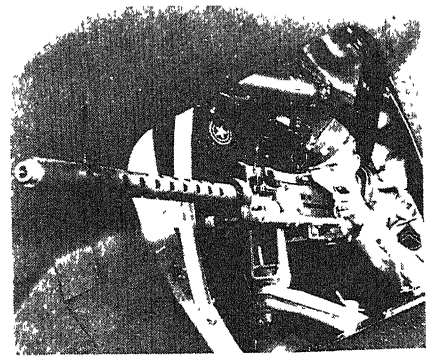
GUN RECOIL

Reduced by Hydraulic Light-Weight Unit

BUILDERS of the P-39, Bell Aircraft has now developed a gun-recoil device which is being used by gunners on many types of bombing planes The device is a portable, light-weight cradle consisting of two steel tubes and a hydraulic absorption unit which can be attached to a .50 caliber aircraft machine gun in a few minutes It adds less



Above: The light-weight cradle of the hydraulic gun-recoil device described in the accompanying note. Below: The waist gunner of a Martin B-26 Marauder lining up a target by the use of the new absorption unit



than an inch to the overall dimensions of the gun and but three pounds to the weight of the mounting. The normal recoil force generated by a 50 caliber gun is so great that, without a damping unit, accurate fire is difficult to achieve. When the recoil is absorbed in the hydraulic mechanism, the gunner tires less quickly, his aim becomes more accurate, and the strain on the structure of the airplane is lessened

Refrigerated Metals

Heat Treatment Has a New and Highly Important Partner in the Cold-Treatment of Metals. Sub-Zero Temperatures are Now Used in Treating and Storing Aluminum Rivets, Shrink-Fitting Mating Parts, Seasoning Steel Gages, and Elsewhere. New Equipment Has Been Developed

AMERICA's fighting men all over the world, times without number have wordlessly thanked the metallurgists and engineers back home for armor plate that successfully withstood shell fire, for shot that pierced the enemy's armament and went on to destroy him, for aircraft engine parts that kept their planes fast and maneuverable during the bitterest dogfights and brought them home safely from the farthest missions

Virtually everyone knows that we have all these—the most resistant armor, the most penetrating ammunition, the most durable and reliable aircraft and ordnance parts—primarily because of our highly developed *heat* treating methods But few outside of the metal-working field are aware of the important part that *cold* treatment of metals and alloys is playing in the production of vital war goods, and of its certain continuing expansion into the post-war period.

Cold treatment—the chilling of metal parts to sub-zero temperatures—is applied to produce a desired effect in the properties or structure of the metal on one hand or to prevent an undesirable change on the other It is sometimes used (1) following a heat treatment to keep the metal in the heat-treated condition Often (2) it is employed in conjunction with heating to produce a special result Or again (3) it may be used to overcome an undesirable effect of a particular heating operation Sometimes (4) cold treatment is used entirely by itself

The refrigeration of aluminum alloy rivets and parts to keep them from age-hardening (and thus to preserve them in the soft and workable condition in which a heat treatment had left them) is an example of the first use just mentioned Metal chilling to produce "shrink fits"—that is, permanently fitting mating machine parts one inside the other by chilling the inside member before the fit is made—falls in either the fourth or second group above, depending on whether the outer member is heated while the inner is chilled. The cold treatment of tool steel and of precision gages during their manufacture to prevent them from warping and distorting over a period of time are applications that would be classed in the second group, for reasons that will be given later

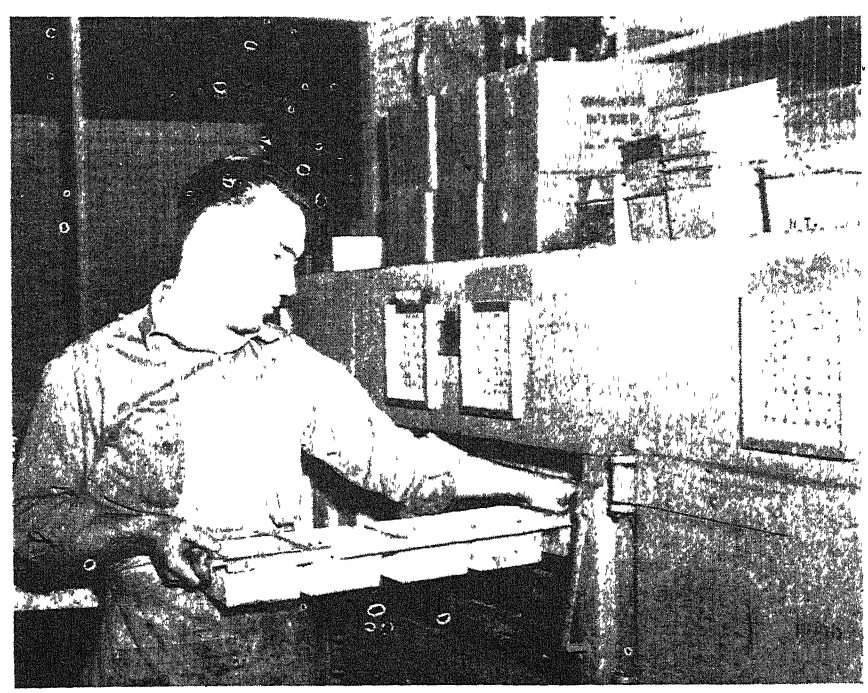
Sub-zero chilling may be accomplished in a variety of ways The simplest is to place the part to be cold-treated in a chamber surrounded with "dry ice" (solid carbon dioxide) or liquid air, or to immerse it directly in liquid air These methods provide temperatures lower than —108 degrees Fahrenheit, and are entirely satisfactory where the chilling of metals is only occasionally or intermittently performed in a plant, and where the control of the sub-zero temperature used need not be highly accurate

FAST COOLING — The considerable growth in use of metal-chilling, much of it on a continuous high-production basis and requiring cooling to closely specified temperatures to produce special effects, has, however, impelled the development of mechanical equipment that can provide very fast cooling and a range of controllable low temperatures, and whose refrigerants are not expensively consumed (as is dry ice) during use This equipment is fundamentally similar in principle to mechanical refrigeration units used in the process and food industries for years, but is specially designed for these newer metal-working applications

The three largest manufacturers of mechanical chilling equipment designed for a wide variety of metal-working applications are Deepfreeze Division, Motor Products Corporation; Kold-Hold Manufacturing Company; and Revco, Inc With the exception of two or three special models that use propane as the refrigerant, all the units made by these companies employ simple mechanical refrigeration systems, either single-stage or two-stage, using Freon 12 or Freon 22 as the refrigerant that is compressed and then allowed to expand and thus absorb heat from the chamber or parts to be cooled Most of the Kold-Hold and Revco units are mobile whereas most of the Deepfreeze machines are high-heat-removing-capacity, stationary units; certain Deepfreeze models provide the lowest temperatures of all—down to —150 degrees, Fahrenheit

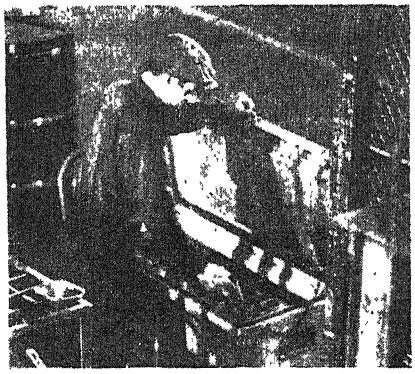
The accompanying table lists some of the common means employed commercially for chilling metal parts, and indicates the approximate lower limit of the temperatures obtained with each

The cold treatment of metals finds one of its widest applications today in aircraft plants, where aluminum alloy rivets and sheets are cooled to low tem-



Refrigerators at a Douglas aircraft plant keep aluminum rivets cold and soft

peratures immediately after quenching and held there to keep them in the "as-quenched" condition—soft, easy-to-drive. The metallurgical reason for this is simple. Certain strong aluminum alloys (17S and 24S) may be heated to 910-950 degrees, Fahrenheit, and quenched to put them in a soft condition; on aging at room temperature they rapidly develop increased strength and hardness. This extra strength and



Portable containers, refrigerated by dry ice, are used to distribute aluminum rivets throughout a factory

hardness are highly desirable in the finished product but they interfere with workability, so the fabricator likes to drive his rivets or form his sheets in the as-quenched condition, before they can age-harden.

If the rivets, for example, can be driven in the "as-quenched" condition, the speed of driving is increased and the danger of rivet cracking is practically eliminated. Therefore, to keep them in this easy-to-drive condition until use, they are refrigerated to temperatures so low that virtually no age-hardening occurs. After the cold, soft rivets are driven they age-harden in place, thereby increasing the strength of the joints.

Refrigeration does not change the final strength of the metal, but merely provides a period of "suspended animation" during which it can be worked with maximum efficiency. Contrary to popular opinion, rivets are *not* refrigerated to provide tighter (shrink) fits in their holes, since at the conclusion of driving the small rivets have reached the same temperature as the parent metal; tight fit is assured by the swelling of the rivet shank under the pressure of driving

Latest research shows that a prompt reduction in temperature after quenching and a continuously low storage temperature before use are essential to maximum workability Age-hardening starts immediately at room temperature (+ 70 degrees, Fahrenheit) and is complete after four days, but if a temperature of + 32 degrees is maintained, no age-hardening will start until 16 hours have passed. Still lower, at 0 degrees, there will be no apparent aging for a week. At the temperature of dry ice (— 108 degrees, Fahrenheit) apparently no aging takes place for a period much longer than that. Because tests have shown that practically no aging occurs after 100 hours at — 40 degrees, temperatures between — 30 and — 40 degrees, Fahrenheit, are most common for the cold treatment of aluminum rivets.

REFRIGERATED ALCOHOL—These low temperatures are obtained by mechanical refrigeration in individual units or by the use of dry ice. Many fabricators promote rapid cooling by using refrigerated quenching water followed by immersion in refrigerated alcohol to remove moisture, since the latter causes a batch of rivets to freeze together like quick-frozen peas in a box.

In large plants, riveting may proceed simultaneously at scores of locations scattered over a large area For this situation rivets are heat-treated and quenched at a central location and transported to the riveting stations either immediately or after refrigerated storage. The portable containers (many of them similar to the tricycle-type ice-

Cooling Method or Mixture	Approximate Lowest Temperature Degrees Fahrenheit
Salt and cracked ice	—6
Mechanical refrigeration (single stage)	—50
Mixture of dry ice and alcohol	—98
Dry ice alone	—108
Mechanical refrigeration (2-stage)	—120
Liquid air	—314
Liquid nitrogen	—410

cream dispensers that once dotted our city streets) for distributing rivets to operators throughout a plant are more often refrigerated by dry ice than by mechanical units.

At the riveting station, however, the rivets are usually stored in large mechanical refrigerators. These are often provided with ingenious and automatic devices for selecting and feeding the right size or type of rivet at the press of a button. One manufacturer provides a canister transfer unit refrigerated with eutectic "hold-over" plates that keep the canisters of rivets refrigerated for two to three hours so that rivets never leave their — 40-degree container from quench to final assembly.

The use of cold treatment for making shrink-fit assemblies involves the broadest temperature ranges to which metal chilling is applied, since each shrink fit involves a different combination of alloys and of part sizes. The technique itself is simple: The inside member—a metal bushing, sleeve, liner —is formed or machined to an outside diameter slightly larger (0.001 to 0.003 of an inch) than the diameter of the hole in which it is to be permanently fitted, then chilled to a predetermined temperature by one of the methods listed in the table. When sufficiently shrunk it is removed from the cold environment and slipped into its mating part. As the temperature of the inside part returns to normal it expands and makes a perfectly tight, permanent fit against the outer member.

The engineer must calculate in advance, from available data on the thermal expansion coefficients of the materials involved and the low temperatures he may use, what allowances and mating-part tolerances should be applied Sometimes (with very long bushings, for example) the shrinkage may have to be several times the actual difference in dimensions to achieve perfect assembly Excessively large shrinkage of the male part may be obviated by moderate heating of the female member to make up the difference

RAPID ASSEMBLY—Shrink fits have several advantages over press fits, in which the two parts are driven or pressed together The assembly can be much more rapidly produced, neither presses nor skilled press operators are required, and there is no scoring whatever of either the male or female member of the assembly The latter remains tight under operating conditions involving vibration, reversing stresses, changes in temperature, and so on, much longer than if made by press-fitting. The process will become increasingly important as handling methods improve and liquefied gases, with the ultra-low temperatures they provide, become available in greater amounts.

Generally speaking, cooling for shrink fits is obtained by one of four principal means—mechanical refrigeration, dry ice, indirect cooling by liquid air, and direct immersion in liquid air. The recent development of the two-stage mechanical units giving temperatures down to — 150 degrees, Fahrenheit, has greatly increased the applicability of mechanical equipment to shrink fits and the trend is now toward this type of equipment.

Here are some typical experiences.

A machine tool builder who formerly

Cold-shrinking the male part of an airplane landing strut assembly

press-fitted bearing cups into their assemblies, now has four mechanical units operating at —50 degrees, Fahrenheit. He turns out each assembly in one third the time formerly required, and the bearing faces are free of the burrs that often accompanied drive fits.

The Ohio Piston Company fitted bronze bushings into pistons back in 1932 by heating the piston and expanding it. This was slow and expensive, so

the bushings were pre-cooled in dry ice and shrunk in liquid air—a process that was still more expensive but much faster Now the company uses two large mechanical sub-zero machines, turns out 17,000 units per month and has brought its costs 'way down despite the added original cost of the two machines

Dodge Division of Chrysler Corporation uses dry ice at — 108 degrees, Fahrenheit, to shrink a 1.5-inch high-alloy cast-iron valve insert and a mechanical unit at — 120 degrees, Fahrenheit, to shrink an 8-inch alloy steel bearing cup, each is soaked 15 minutes at the low temperature and both shrink 0 002 inch. Other parts treated by Dodge in its mechanical refrigerators are seals, gear hubs, drive shafts, spring lever pins, and shock spring pins.

Ford Motor Company has been shrink-fitting valve seats in cylinder blocks for 10 years. For some work requiring the greatest amount of shrinkage, direct immersion in liquid air is employed. For example, a bronze sleeve for a gun mount, 10 inches long, 6 880, 0 002 of an inch outside diameter, 0 205 of an inch wall—is shrink-fitted into a tube whose inside diameter is 6 875 + 0 002 inch by immersing it for 15 minutes in liquid air. Other prominent shrink-fit jobs at Ford are the assembly of small aluminum bushings in aluminum castings, steel sleeves in aluminum cylinder blocks, iron sleeves in iron cylinder blocks, bronze bushings in steel castings, and steel inserts in aluminum forgings.

Another manufacturer assembles airplane landing struts by shrinking a 4 843-inch inside member 0.003 of an inch with a five-minute treatment in a — 120 degree, Fahrenheit, mechanical unit and expanding the same-size outer member 0 005 of an inch with a five-minute immersion in a 450 degree, Fahrenheit, oil bath.

Liquid nitrogen, whose temperatures may be as low as — 410 degrees, Fahrenheit, is used by General Electric's Schenectady works to over-shrink steel parts that must be fitted into tungsten carbide cylinders.

GAGE TREATMENT—The stabilization of precision gages and machine parts is a cold-treating application that is many years old but which has recently received new prominence and a sudden expansion in use. These have come about through the development of mechanical refrigerators that go down to — 150 degrees and which thus synchronized cold-stabilization with the tempo of war production, and through new metallurgical understanding of the structural changes ocurring inside the steel.

Practical men have known for decades that the dimensions of a gage block, for example, are unlikely to remain stable after its manufacture is completed but will change, through distortion and growth, as much as 20 times the tolerance over a period of time. For this reason heat-treated gage blocks were traditionally stabilized by leaving them outdoors for several years until all warping had spent itself, after which they could be finish-machined to final, precise dimensions and would be perfectly stable from that time on More recently the practice has been to rough-machine and harden the block, then allow it to age for one to three years, and finally hold for a matter of hours at — 50 degrees, Fahrenheit, before finish-machining

Rapid assembly of bronze piston bushings is accomplished by chilling the bushing prior to insertion

Modern gage manufacturers have tremendously speeded up the necessary stabilizing process by applying the most recent research findings on steel transformations, together with chilling temperatures as low as — 120 degrees, Fahrenheit The trouble with the gages in the first place is that the change in structure that quenching and tempering of the steel is supposed to produce is not completely accomplished when the quenching temperature is the conventional + 60 to 200 degrees, Fahrenheit. The "suppressed desire" of the steel to complete that change then proceeds to find release very slowly over a period of years at normal temperatures, and in doing so warps the gage out of size. However, as Dr Morris Cohen and his associates at Massachusetts Institute of Technology have recently demonstrated, this change will be completed at the beginning if the steel immediately after quenching is brought down to — 100 to — 150 degrees, Fahrenheit, for a suitable time.

Commercial processes have therefore now been developed whereby steel gages, gage blocks, mandrels, spindles and so on are completely "seasoned" or "stabilized" in about 48 hours by hardening and quenching in the usual way, chilling to — 120 degrees, Fahrenheit, tempering at a selected temperature above 300 degrees, and then repeating this cycle five times. Satisfactory stabilization for most purposes is also claimed for similar cycles using chilling temperatures in the neighborhood of — 50 degrees.

What this has meant in faster production of war equipment and in greater precision and therefore better quality defies description. But of greater interest to some is Dr. Cohen's belief that sub-zero hardening and tempering of high-speed tool steel will produce combinations of hardness, strength, and ductility unattainable by ordinary methods.

Post-war planners are watching refrigeration in the metal industries with interest, for in addition to all the foregoing growing and evidently permanent uses there are many others, such as the chilling of cooling and quenching oils to improve metal-cutting and heat treating operations, that have intriguing possibilities

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VIBRATION FAILURE

Reduced Through Surface Stressing

NOTABLE among recent engineering trends in the metal industries has been the growing use of surface strengthening treatments to improve the "fatigue resistance" of metal parts and thus cut down vibration failures in service. A fatigue failure is the breakage that results after a tiny surface crack or disparity has been enlarged progressively, through the debilitating effects of vibration or cyclic stress reversals, until it reaches across the part. Fatigue failures are responsible for a large portion of the breaks that occur in axles, airplane components, overhead cables, electrical machinery, bearings, shafts, and so on

The fatigue strength of a part, declares J. O. Almen of Research Laboratories Division, General Motors Corporation, will be increased if a thin layer of the material is pre-stressed in compression by peen-hammering, swaging, shot blasting, tumbling, and so on. Possibly the most widely used of these treatments for this purpose is shot blasting which is now frequently specified as a final cleaning operation because of its salutary effect on fatigue strength.

Case hardening may also be used to improve surface fatigue properties. Of all the case hardening methods, nitriding seems to be the most desirable from the fatigue resistance standpoint

CAST CRANKSHAFTS

Replace Forged Units, Prove Adequate

A STRIKING illustration of the great improvement in the quality of iron castings in recent years, and of the heavy-duty applicability of specially processed cast iron, is afforded by the current replacement of forged steel by Meehanite iron castings for Diesel crankshafts made by Cooper-Bessemer Corporation. The iron castings are easier to obtain, require less machining, involve less waste metal, and have adequate properties for this type of service

In one series of operating tests forged shafts of 0.45 percent carbon steel were replaced with cast Meehanite shafts The crankshafts were six-throw units 7 feet 8 inches long and were run at 1000 pounds head pressure for 40,000,000 revolutions at 900 revolutions per minute without any damage to the cast crankshaft or its bearings.

Plastic Flow and Creep

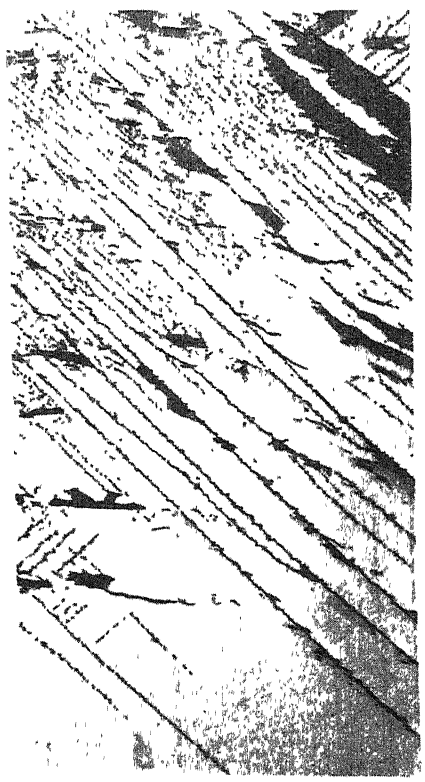
Not Enough is Yet Known About the Exact Mechanism of Metal Flow and Forming. More Knowledge Will Bring Metal Improvements, also Financial Savings. The Immediate Need for New Knowledge of the Plastic Flow in Metals is for the Rapidly Evolving Gas Turbine

By A NADAI

Consulting Mechanical Engineer, Westinghouse Research Laboratories
East Pittsburgh, Pennsylvania

IN PEACE and war the machine industry requires vast quantities of metallic bars, plates, sheets, and tubes Each day the steel mills must supply thousands of tons of these simple bodies, which must be forged, rolled, drawn, and shaped from ingots. Anybody who has watched the rolling of broad steel sheets for automobile bodies in one of the huge continuous strip mills must have admired the high precision of the operation. A wide, hot sheet goes through one roll stand after another at ever-increasing speeds and emerges finally with a velocity of 20 to 30 miles per hour, ready to be wound on a reel In wartime, huge quantities of thin, light metal sheets are needed to build airplanes. Also, much thicker plates of ship steel and armor plate are in heavy demand.

Great progress has been made during the last 10 to 15 years in the mass pro-



These plastic flowlines on steel after permanent deformation tell us a tale

duction of metal shapes, but this progress has been mainly of a practical nature. When comparing it with the great developments in other branches of mechanical engineering—for example, in building large steam turbines, generators, combustion engines, or planes, the designs of which are all based on exact mechanical knowledge—it is rather surprising to note how little, comparatively, is known about the exact mechanics of metal forming. The flow of steel under heavy concentrated pressures exerted by a rolling mill is not well understood Little also is known about the power losses through friction during rolling, or concerning the true forces required to deform cold or hot steel This is the more surprising since the power requirements of large rolling mills run into many thousands of horsepower and these power requirements can be judged, therefore, only in an empirical way.

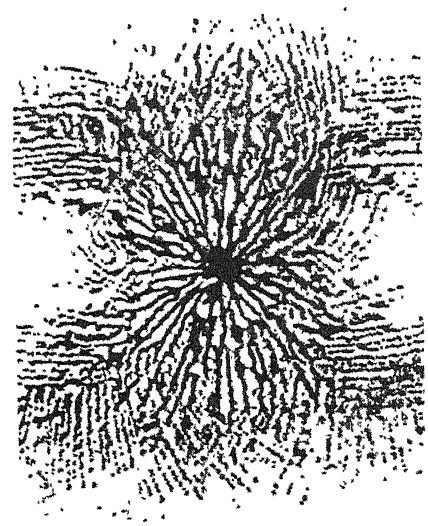
When a wire is drawn, or a bar or a wide sheet is rolled, or a seamless tube is formed, or a billet is pierced, or a high-explosive shell is nosed in some of the many ingenious and intricate forging machines of a steel mill, heavy localized pressures are utilized. Usually these pressures are combined with other forces to pull or to push the piece under the rolls or dies Although the metals are in the solid state, they flow easily at forging temperatures under concentrated pressures without breaking, not unlike soft wax or wet clay being extruded from an orifice Use is made of their "ductility" or "plasticity"

POWER SAVINGS—The art of forging is as old as the making of the first metallic implement of earlier man, yet many important cases of the plastic flow of solid materials under concentrated pressures have barely been investigated mechanically A better understanding of this flow of metals should result in steel-mill power savings and improvements in the structure of the metals produced.

A wonderful mechanism is hidden in the plastic deformations of a metal. This is illustrated by the accompanying photographs which show examples of remarkably regular patterns. These "flowlines" appear on the surface of mild steel plates after a small plastic deformation. Should these regular designs not inspire the mechanically inclined observer to further thinking? Engineers have often called attention to these fine markings. The geometry of these lines seemed to disclose to them that simple mechanical or physical laws must control these phenomena. Other examples of a striking regularity are known to the physics or mechanics student, such as the force lines of Faraday around magnets, or the streamlines in a moving fluid around solid bodies, yet to forestall any confusion, the flowlines in a metal should not be identified with some of these well-known patterns in physics They have their own and a different mechanical meaning. Just as Faraday's magnetic force lines have attracted the attention of mathematicians and inspired them to analyze the electric or magnetic static fields, it is believed that these patterns of flow may help to analyze the plastic states of equilibrium when solid bodies are deformed permanently.

Reasons why engineers should be interested in the phenomena of the plastic flow of materials, other than those involved in the forming of metals previously mentioned, will be found in the following paragraphs

Many of us have seen how the con-



Another flow picture on a steel plate. Its black lines are the traces of instantaneous differential slip motions under a concentrated central force. Plate supported on four margins

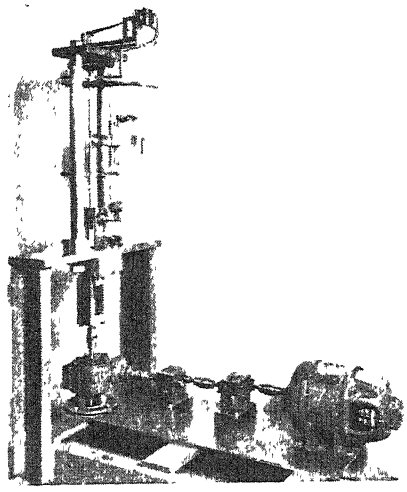
tinuous strip mills revolutionized steel-making but only the older engineers remember another revolution that was even more astounding—the rise of the steam turbine which almost overnight replaced the bulky and slow triple-expansion steam engine. This sudden eclipse could not have occurred if engineers and scientists had not prepared the ground to solve the problems which presented themselves suddenly with the steam turbine. Thermodynamics was well advanced There was an excellent contemporary knowledge of the thermomechanical properties of water vapor Engineers were able to solve a number of difficult mechanical problems which were raised by the steam turbine

Many present signs of development indicate that something similar may possibly occur in the next few years, with the gas turbine replacing its older steam-driven rival for many purposes It does not require the costly installation of boilers and condensers and it is much simpler in design. It needs, however, a rotary compressor of high efficiency for compressing the air Strange as it may sound, aerodynamics was partially instrumental in perfecting this auxiliary machine Rotary pumps and steam and gas turbines all contain hundreds of blades in their wheels, and their efficiency has been improved greatly through the better knowledge of the flow of air around the wings of planes studied in the aerodynamic laboratories.

The theoretical means for predicting and controlling the flow of steam through nozzles and around blades, the designs of the highly stressed rotating disks, the method for computing the critical speeds of the flexible shafts, and many other difficult problems, were clearly stated or solved for the steam turbine by the great engineer and scientist Aurel Stodola, who died a year ago in Switzerland He developed the theory of the steam turbine when De Laval, Parsons, Rateau, and others succeeded in building the first practical steam turbines Stodola had foreseen the theoretical means for designing gas turbines 30 to 40 years ago when the first noteworthy efforts were made to build experimental gas turbines. He constructed the first graphical entropy —temperature chart for the valuation of the efficiencies of thermal cycles This was based on the variable specific heats of gases

WHAT DELAYED IT?—Since the theoretical means for building gas turbines have been available for so long, why then has the gas turbine not already replaced the steam turbine? Mainly because of the lack of materials which will resist the high temperatures at which the gas turbine must operate to make it the economic superior of the steam turbine. Alloy steels capable of standing the punishment handed out in the gas turbine have been developed only recently and satisfactory means of predicting the mechanical properties of these steels are comparatively quite new The engineer designing a gas turbine, which must operate at 1200 up to 1500 degrees, Fahrenheit, encounters these difficulties. He has to give up some of the conservative ideas of former times, for example that the dimensions of highly stressed machine parts will remain the same during the lifetime of his machine Parts made of the strongest alloy steels start and continue to yield under these high temperatures The slow "creep" which could be checked in steam turbine design becomes disturbingly fast in gas turbine disks or blades

The property of the ductile metals of flowing plastically is most desirable in



The constant strain tension machine

making steel products. But when it occurs as "creep" in machine parts under heavy loads at high temperatures it is dangerous and detrimental The blades of a steam turbine, whirling continuously for years at a temperature of 900 degrees, Fahrenheit, with their tips clearing the stationary part of the machine by only a few thousandths of an inch, creep so slowly that they need not be exchanged during the life of the turbine—20 years or more. Gas turbine blades spinning at 1500 degrees, Fahrenheit, present the same problem under very much more difficult conditions. This is true also in other applications Engineers designing containers, petroleum distilling equipment, steam boilers designed for high pressures, and many other types of apparatus must know as exactly as possible how their materials will behave and creep under stress at high temperatures. The structure of metals exposed to hot air or gases may also be so weakened that the danger of fracture may become quite a determining factor.

Mechanically trained and similarly interested readers probably will conclude from the preceding remarks that the strength of solids in general and of engineering materials in particular must embrace a complex group of mechanical properties which must be associated with a variety of phenomena. More precisely, "strength" is not just *one* mechanical property. Several important cases representing types of "strength" must be differentiated. In each case "strength" may depend on a number of important variables.

Statics teaches that if the external forces acting on a body are in equilibrium, any portion or small element of material in the body must also be in such a state. The interior of solid bodies carrying external loads must therefore be internally "stressed" Tension, compression, shear, and hydrostatic pressure are such states of "internal stress"

It is an accepted practice that constructions made of steel, which have to carry a permanent load at normal temperatures, are to be designed so that the yield-point is not reached in them at the most stressed point

Solids under stress may change their shape either by very small amounts which are recoverable after the loads are removed (elastic distortion) or they may start to deform permanently A geometry of all these changes of shapes of solid bodies has long been developed and serves as a tool in engineering design The term "strain," so much used by engineers, serves to designate the general status of deformation, either elastic or plastic. If time also plays an important part, as under elevated temperatures, apart from "stress" and "strain," a third variable becomes quite important. A glass rod held in a horizontal position in a gas flame will start to sag under its own weight when it has become soft The more weight it has to carry the faster it will sag Thus we see that stress in this case does not depend on the permanent strains but on the *rates* at which they are changing, that is, *on the rates of flow or of strain.*

In sum, then, stress, strain (elastic or permanent), the rate of permanent strain, temperature, and time are the principal variables to be considered and the study of strength and of the mechanical behavior of solids must mainly be concerned with defining the relations connecting stress with strain and with the rate of plastic strain. The conditions under which materials rupture, break, and fatigue embrace other important chapters of the theories of strength

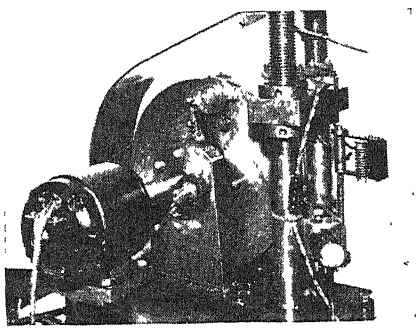
ROCKS THAT FLOW—Although the strength of solids is deeply anchored in the atomic structure of matter, and that of certain important metals or alloys is materially influenced, improved, or altered through metallurgic (heat) treatment, it is equally true that certain frequently used and familiar designations expressing important material properties depend on the mechanical states under which these properties are being compared An example will illustrate this. A test cylinder of marble or of sandstone under a simple compression load deforms very little before it breaks Such materials are called "brittle." If, however, the test cylinder is surrounded by a fluid in which a high pressure has been generated and if the fluid is prevented from penetrating into the pores of the cylinder, then the cylinder can be deformed in a plastic state quite continuously under an additional axial compression load without fracturing. The celebrated Swiss geologist, Albert Heim, perceived long ago, with other geologists, that something similar must have occurred in the depths below ground in certain rock formations. Geologists are familiar with this behavior of rock materials in the interior of the earth's crust today.

Many symptoms point to the fact that the rocks have been deformed continuously and permanently without showing any signs of fracture. "Brittleness" in marble or sandstone thus does not seem to represent an inherent property of these materials. A brittle marble can be continuously deformed plastically under the proper conditions

Another example of varying mechanical states can be found if a steel ball is laid on the surface of solid asphalt which fills a vertical tube of which both ends are open. After a few sufficiently hot summer days have passed, the ball will be found at the bottom of the tube. The solid asphalt must have yielded under the weight of the ball and behaved like a viscous liquid since it could continuously flow around the ball. A piece of the same natural pitch, on the other hand, if it is thrown violently against a wall or the floor, will break into many fragments. The same material behaves in one case like a "viscous liquid," and in the other like a "brittle solid."

SLOW AND FAST TESTS—We shall now concentrate on one of the fundamental variables: The permanent *rate* of strain Let us investigate the magnitudes of this rate under difficult testing conditions encountered in slow and in very fast tests. A very slow test is, for example, a long-time creep test run at an elevated temperature. Toward the other extreme, the flow accompanying the penetration of a projectile hitting an armorplate must occur under extremely rapid rates of straining. A bar of a ductile metal, such as copper under a tension load, can stretch by an amount which is 30 to 50 percent of its original length before it will break. If a bar is stretched by 100 percent, this is equivalent to saying that the strain is equal to "1". If strain=1 is produced in one second the rate of strain is equal to 1/sec. If strain=1 is produced in one year the rate of strain is equal to 1/year. Therefore, assuming that an ordinary tension lasts 15 minutes (900 seconds), the rate of strain is of the order of 0.001/sec. or a fraction thereof. During a fast impact test a bar may on the other hand be stretched by 50 percent in a ten-thousandth of a second. Plastic rates of strain in impact testing may reach the order of 10,000 1/sec. Steam turbine engineers require that no essential part of a turbine should change its shape by more than 0.001 of its original dimensions in 10 years of service. This corresponds to the very slow rate of strain or of creep of 0.0001 1/year, or 3.2 times one billion billions 1/sec. (that is, 3.2×10^{-12} 1/sec.)

Geophysicists are interested in many times smaller rates of flow. Creep in rocks must evidently have a significant part in the mechanism of mountain building The temperatures below ground increase an average of 1 degree, Fahrenheit, for every 60 feet of depth. At depths of a few kilometers temperatures must reach several hundred degrees, Centigrade. Under such temperatures, granitic or igneous rocks certainly must creep even if they are subjected to extremely small gradients of differential stress According to geophysics, the whole geologic history of



High-speed tension machine. Its flywheel carries two horns which can be released during rapid rotation, hitting an anvil and delivering a powerful blow to the test bar

the earth from the times of beginning (forming of the oceans) covers not more than 2000 million years. If we take perhaps one twentieth, or 100 million years, as the average length of a geologic epoch and if a fraction of this latter, say 10 million years, was sufficient to produce a mighty mountain range like the Himalayas, and if we finally assume arbitrarily that all horizontal lengths in the direction perpendicular to this mountain chain have been reduced to 50 percent of their orignal values, a rate of flow in the rocks in horizontal direction would be found equal to 5 times 10^{-8} 1/year. Thus the slow creep rates in a steam turbine disk are more than 10,000 times faster than the geologic flow which caused the lifting of a high mountain range. The total range of the rates of plastic strains of interest to engineers covers a range 10^{16}:1 and if geophysics also is to be included in our discussion, this may well be extended to 10^{20}:1 or more.

We have noted that at the higher temperatures stresses which deform materials depend on the rates of flow, rather than on the strains. We can now add that the inner resistance of solids against a rapid permanent deformation at sufficiently high temperatures must increase quite considerably with the rate of strain This has recently been shown in some high-speed tension tests which were run at the Westinghouse Laboratories in Pittsburgh with copper at the very rapid (impact) rate of 1000 1/sec near the melting point of the copper. It was found that copper at 1000 degrees, Centigrade, (it melts at 1083 degrees, Centigrade), when stretched violently at such a high velocity (a copper bar one inch long was broken in 1/1000 second), resists with a strength that is as large as a third of the strength of copper at 20 degrees, Centigrade Copper under normal or slow rates of pulling at 1000 degrees, Centigrade, would not be able to carry any substantial load

Among the physical phenomena, plastic flow of solids attracts interest because of the extremely wide range over which one important variable on which it depends can vary Few phenomena are known to the writer in physics for which the variables change over a range of 10^{20} in the applications Only the electromagnetic spectrum surpasses this scale. This is further illustrated through a comparison of equally spaced phenomena in both scales, as in the accompanying table.

LONG TESTS—Readers will perhaps be interested to know whether experiments have been carried out for testing engineering materials at some of the above-mentioned extremes of the velocities. This question can be answered affirmatively. In the engineering laboratories many careful investigations are carried out at present on the long-time creep strength of metals, particularly on alloy steels. The slowest tests of this kind may need many months for their completion Creep rates will be of the order appearing in the second column of the table One of the photographs shows a constant strain rate machine, in which a small test bar seen between the two vertical columns can be pulled under the rather fast strain rates of 10^{-3} to 1 1/sec. Extremely rapid plastic deformations approaching those accompanying an explosion or corresponding to impacts in steel pieces are produced in the high-speed tension machine shown in another photograph, in which a one-inch-long tension bar can be broken in one thousandth of a second.

In sum, we can then perhaps state that in forging operations, strain rates are reached of the order of 100 1/sec. Metals at the forging temperatures flow easily under these rates without breaking. Metal forming is based on the ease with which metals can be deformed at the forging heat. Under impact, even one hundred times faster flow rates can be attained. In other applications of engineering, however, creep and plastic flow are undesirable. If they cannot be prevented, as in the applications in which machine parts have to withstand very high temperatures, the engineer, through his tests, must in advance determine the stresses under which the strain rates in his constructions will not exceed permissible limits.

Flow Of Solids	Rate of flow per sec.	10^{-16}	10^{-12}	10^{-3}	10^{4}
		(geology)	creep in steam turbines	ordinary material testing	explosion damages
Electro-magnetic Phenomena	Frequency per sec.	10^{2}	10^{6}	10^{15}	10^{22}
		low frequency electric heating	high frequency	visible light	cosmic rays

Plastic flow and electromagnetic spectrum, for comparison of ranges

Gasoline From Coal

Highly Important in this Solution to the Problem of Our Dwindling Petroleum Reserves is the Study of Coals and their Adaptability to Processing into Liquid Fuels. Technical Data Must be Acquired Before the Crisis Arrives; Experimental Plants Will Provide Data for Industry

By REPRESENTATIVE JENNINGS RANDOLPH
Chairman of the House Sub-committee of the Committee on Mines and Mining

IN THE post-war era millions of new automobiles will travel on improved highways; helicopters and planes by the thousands will be piloted by men now flying fighters and bombers; larger and faster commercial transport aircraft will span oceans and continents on hourly schedules. All these planes and automobiles must be powered with liquid fuels.

On one hand there is a promising future for our country, with a vast increase in air transportation, fast aerial service to foreign lands, rapid development in the use of private planes, and the resumption of our normal automobile manufacture and use. On the other hand, the picture may be changed entirely if our petroleum reserves become seriously depleted and if, in the meantime, we fail to develop ways for producing fuel from other materials.

The recent decline in the rate of discovery of new petroleum fields in this country has given rise to the question of what we can do to meet the demands of an air-minded and automotive post-war age. Since 1939, petroleum has been consumed at a greater rate than it has been discovered in new fields not previously known. Also, oil fields discovered in recent years have been of relatively small capacity. With an all-time high (1,402,228,000 barrels in 1941, and higher now), we cannot continue to drain sources which are already being depleted Last year the new oil found was a half-billion barrels less than we produced. Since 1937 the number of new pools found has increased but the quantity of oil has consistently fallen off.

While our oil reserves, tucked away in strata of the earth's crust, is estimated at 20 billion barrels and we are now using less than one and six-tenths billion barrels a year, geologists maintain that it will take 50 years to get today's known reserve supply above ground, and some say that a century will be required to bring it up.

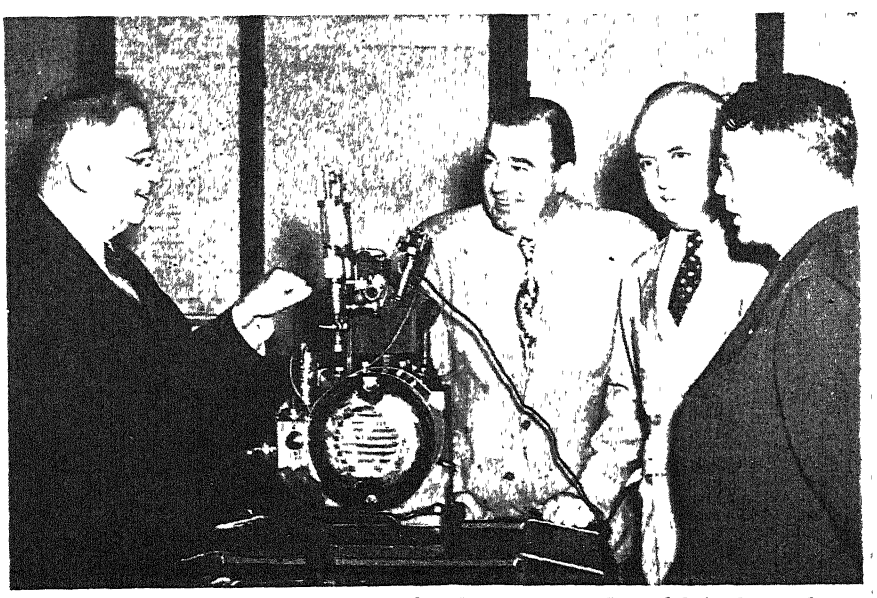
MANY FIELDS EXHAUSTED—Oil men do not have much to offer in the way of encouragement; the big fields have apparently been discovered and many have already been exhausted. The newer fields are smaller and the costs of exploration and drilling are necessarily higher. To estimate exactly how long the available supply of oil will last this nation is virtually impossible. Experts in the oil industry say that there will be an acute shortage in 20 years. Others equally qualified say that new fields will delay this shortage for 50 years.

But there is a reasonable prospect for securing the liquid fuel necessary for the construction and expansion of automotive transportation on land and sea and in the air from other sources which will be available for many years Great Britain, Germany, and Japan are making synthetic oil and gasoline by processes that are known to have passed the experimental stage Great Britain produces enough gasoline by coal hydrogenation to keep 100 to 200 bombers over Germany every night; a lower octane gasoline and Diesel oil is obtained from oil shale Germany is said to produce over half of her liquid fuel from coal and coal tar, while Japan is likewise reported to produce large amounts of liquid fuel from coal and oil shale.

In order to round out the over-all picture of motor fuels from coal, we should first review the by-product processes Of these there are two (1) The high-temperature carbonization of coal, including that used by the gas-and-coke-manufacturing industry; and (2) The low-temperature carbonization of coal

In coke and gas works about 2 5 gallons of refined motor benzol can be obtained from the ten gallons of tar produced in the high-temperature carbonization of one ton of coal. On this basis, 207,000 000 gallons of motor benzol could have been obtained from the total coal coked in by-product ovens in the United States during 1941, or about 0.7 percent of the 29,000,000,000 gallons of motor fuel produced.

Low-temperature carbonization is



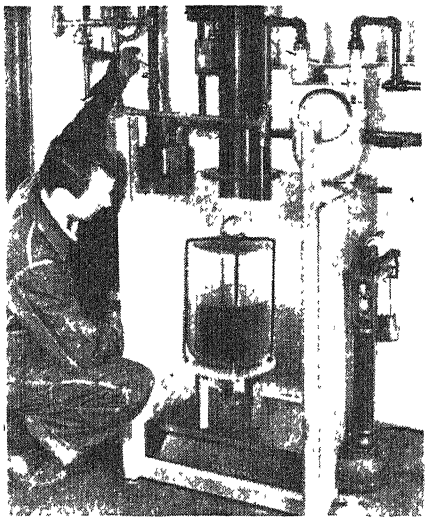
Left to right: Secretary of the Interior Ickes, Representative Randolph (author of the accompanying article), Senator Murdock of Utah, and Senator Gurney of South Dakota, with a gasoline motor being operated on synthetic fuel produced from coal at an experimental plant (see diagram, next page) operated by the Bureau of Mines

often cited as the process that will solve the problem of our future motor-fuel supply In this process coal is heated to about 1100 degrees, Fahrenheit, instead of the approximate 2000 degrees used in high-temperature carbonization The tar yield is 20 to 35 gallons a ton, or two to three times that obtained by high-temperature carbonization From one to two gallons of liquid fuel can be scrubbed from the furnace gas, and another gallon or two distilled from the tar, the total yield being two to four gallons. Refining losses would bring the net yield of motor fuel from gas scrubbing and straight distillation of the tar to about 2 5 gallons a ton, or about the same as is obtained in high-temperature carbonization However, this low-temperature tar may be subjected to pressure-cracking similar to that applied to petroleum, and thus made to yield 20 to 30 percent of motor fuel It is, therefore, reasonable to assume a possible yield by this process of 7 to 12 gallons of motor fuel per ton of coal

TEN GALLONS PER TON—If 100,000,000 tons of bituminous coal, about one fifth of the output in 1941, had been carbonized at low temperatures, the motor-fuel yield on the basis of ten gallons to the ton would have been one billion gallons, or about 4 percent of the gasoline production in that year

It is evident that the maximum probable development of the production of motor fuel as a by-product of low-temperature carbonization of coal, while furnishing a material quantity, cannot satisfy the entire demand We must turn, therefore, to other processes, including hydrogenation, in which motor-fuel is the principal product rather than a by-product.

Coal hydrogenation is similar to other forms of coal utilization, in that among the major factors involved are the nature and properties of the coal Choosing the best coal for the job is most important By using coal of optimum properties, the yield of oil is increased, the amount of inert residue is decreased, operating difficulties and maintenance costs are minimized, and the capital investment and cost per gallon of the product are lowered.



Gasoline from coal flows directly into containers from the converter room where the coal is hydrogenated

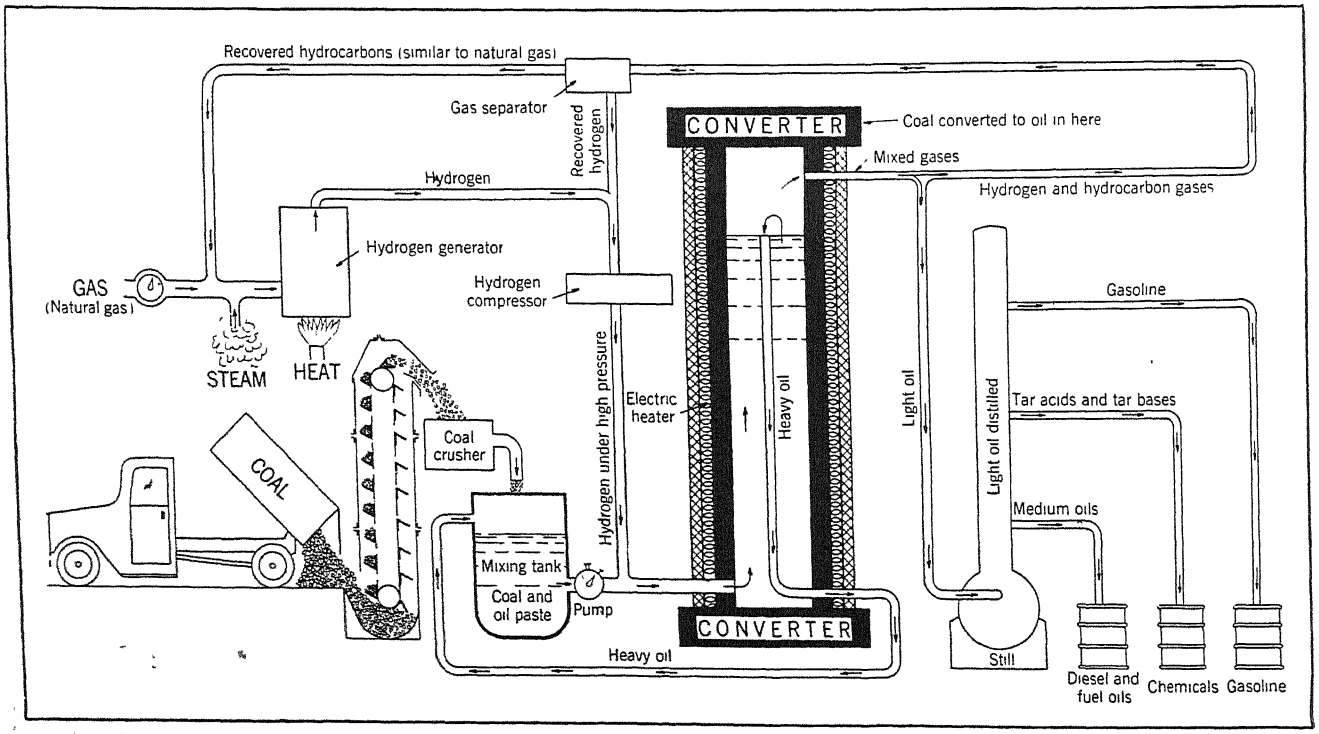
Data obtained in the hydrogenation of about 130 samples of pure constituents of coal or of coals of known petrographic composition show that some of the constituents differ enormously in ease of liquefaction and yield of the various products.

Continuous hydrogenation tests of low-rank coals in the Bureau of Mines Experimental Plant, in which no undue operating difficulties were experienced, show that the coals in some of the vast deposits of the western states are potential sources of enormous quantities of liquified fuels, solvents, synthetic resins, and industrial chemicals

In bituminous and lower-rank coals the constituent that usually has the highest degree of opacity and the highest carbon content is fusain This constituent, which resembles charcoal in appearance, is a mixture of opaque fibers, called "fusinite," and about 10 to 30 percent translucent or semi-opaque material The "fusinite" is virtually inert to hydrogenation, but the material associated with the opaque fibers is partly, sometimes almost completely, liquefied by hydrogenation The liquefaction yield, which depends primarily on the quantity and nature of the translucent fraction, usually ranges from 5 to 25 percent

As may be concluded from the foregoing, bright coals, which contain high percentages of translucent material and comprise the greater part of the Nation's coal reserves, usually are suitable for hydrogenation The liquefaction yield obtained upon hydrogenation of bright coals containing less than about 10 percent total opaque matter is related to the carbon content. A high liquefaction yield is obtained with bright coals having less than about 89 percent carbon. The yield of oil decreases and that of water and carbon dioxide increases with a decrease in the carbon content of the bright coal hydrogenated

As a class, splint coals (banded coals containing 30 percent or more of opaque attritus, the latter being the characteristic constituent of splint coals) are less suitable for hydrogenation than bright coals. In contrast with bright coals, splint coals are highly heterogeneous, their carbon content, volatile-matter content, and other characteristics are only averages for all the constituents. Hence, upon the basis of carbon content and opacity, the constituents of splint coals differ enor-



Simplified flow diagram of the conversion of coal to liquid fuel, as accomplished at the Bureau of Mines' hydrogenation plant

You owe it to your Uncle Sam!

He needs manpower—every available person. A hearing deficiency may keep you out of the armed forces . . . but you can do your fighting on the home front . . . in war material plants. A good hearing aid enables you to go all out in the war effort. The movement is growing. In our plant today are workers wearing hearing aids and contributing as competently as if their hearing were normal.

The New Zenith RADIONIC
HEARING AID

ACCEPTED
By American Medical Association Council on Physical Therapy.

$40.00 READY TO WEAR

Complete—with Radionic Tubes—Crystal Microphone and Batteries
. . . *Liberal Guarantee*

●

You owe it to your friends!

They want to enjoy your company as much as you do theirs. Your hearing aid means as much to them as it does to you.

Are you really doing your part?

That question only *you* can answer. *Think!*

Report on a Revolution

Zenith recently started a revolution—to reduce the *cost of hearing*. After years of research and preparation, the Zenith Radionic Hearing Aid is now offered to the public.

The price—$40—(about one-quarter that of other good vacuum tube instruments). Complete—ready to wear—with miniature radio tubes, crystal microphone and batteries—liberally guaranteed.

Inquiries from everywhere have flooded the mails—telephone calls—telegrams.

A sales volume—unheard-of in this field—is gaining daily momentum—and is a demand created by self-evident merit of the instrument itself. Today our problem becomes one of production and distribution—to as quickly as possible make the Zenith Radionic Hearing Aid available in all localities.

We are doing our best to furnish additional manpower for Uncle Sam's production forces. And—in the doing—we are experiencing that rare satisfaction born of directly contributing to the welfare of individuals.

THE ZENITH HEARING AID WILL BE AVAILABLE THROUGH REPUTABLE OPTICAL ESTABLISHMENTS FRANCHISED BY ZENITH. (NO HOME CALLS OR SOLICITATIONS)

We'll be glad to advise address of outlet nearest to you

Zenith has built the best that modern knowledge and *radionic* engineering make possible into this $40.00 hearing aid. It has no other models . . . *one* model . . . *one* piece . . . *one* quality.

There are cases in which deficient hearing is caused by a progressive disease and any hearing aid may do harm by giving a false sense of security. Therefore, we recommend that you consult your otologist or ear doctor to make sure that your hearing deficiency is the type that can be benefited by the use of a hearing aid.

TO PHYSICIANS

A detailed scientific description will be sent upon request. Further technical details will appear in medical journals.

Write for Free Descriptive Booklet
ADDRESS DEPT. S.A.-2, HEARING AID DIVISION
ZENITH RADIO CORPORATION
CHICAGO 39, ILLINOIS

ZENITH
•LONG DISTANCE• RADIO
RADIONIC PRODUCTS EXCLUSIVELY—
WORLD'S LEADING MANUFACTURER

mously in rank and, therefore, in value

The results obtained with the low-rank coals from the Western States, which comprise the greater part of the United States coal reserves, are of special interest. Of the low-rank coals examined, the majority contained only small quantities of opaque matter and gave a low yield of inert residue upon hydrogenation. The opaque-matter content of some coals was so low that virtually all of the organic part of the coal was liquefied

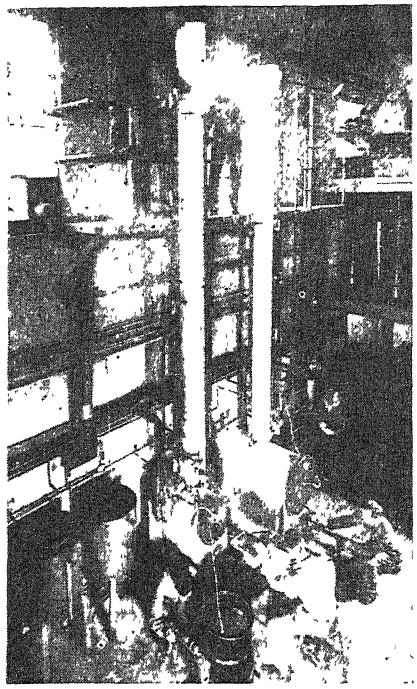
Since the beginning of coal-hydrogenation research (about 1913), one important objective has been to determine which coals will give the highest yields and fewest operating difficulties when processed to produce liquid motor fuels. This brings us to a brief description of the two direct processes which have been developed for this purpose·

(1) The hydrogenation and liquefaction of coal by the modified Bergius process which produces gasoline, Diesel fuel, and fuel oil This process was developed by the I. G Farbenindustrie A.g. of Germany.

(2) The complete gasification of coal and catalytic conversion at varying pressures, as stated below, of the resulting mixture of hydrogen and carbon monoxide into gasoline, Diesel fuel, lubricating and fuel oils, and paraffin wax. This is known as the Fischer-Tropsch process.

HYDROGENATION—In the modified Bergius process a coal-oil-catalyst mixture containing 40 to 50 percent of powdered coal and 0.1 to 1 percent of a powdered catalyst is forced into a high-pressure vessel with hydrogen gas at over 200 atmospheres pressure and at a temperature of about 860 degrees, Fahrenheit. After some two hours contact time the coal is liquefied and the product is separated into gasoline, middle oil, and heavy oil. The latter is recycled to provide oil for mixing with coal at the start of the process. The middle oil is hydrogenated further, using a catalyst held in place in the converter rather than pumped in with the raw material. The final products are gasoline and Diesel fuel. About 50 percent of the coal that is hydrogenated is obtained as a motor fuel and about five tons of coal are necessary, per ton of gasoline produced, to provide fuel for all purposes, including power, steam, and so forth.

In the Fischer-Tropsch process, developed by Dr. F. Fischer in Germany in 1926, the raw material is a mixture of hydrogen and carbon monoxide gases produced from coal or coke. This gas mixture, after purification to remove all sulfur compounds, is passed over a solid catalyst such as a mixture of cobalt and thoria with diatomaceous earth. The temperature is maintained between 356 and 410 degrees, Fahrenheit, and the pressure between 1 and 50 atmospheres. The valuable products are propane, butane, gasoline, Diesel fuel, and paraffin wax. About four to five tons of coal are necessary per ton of products. The cost of production probably is in the same range as that for direct coal hydrogenation.



Small cracking plant where medium oil obtained from the first stage of coal liquefaction is fractionated to produce more gasoline, Diesel oil

The Bureau of Mines' experimental coal-hydrogenation plant at Pittsburgh, Pennsylvania, has a capacity of 100 pounds of coal in 24 hours. The main objective of the plant's operation thus far has been to study the hydrogenation of coals from the most important coal beds in the United States

While motor fuels can now be produced from coal and oil shale, these sources do not offer as cheap a supply as does petroleum. But I feel certain that our people will back the extra effort and the extra cost when the alternatives are ample or restricted supplies of gasoline. Furthermore, even though production cost is higher, further technological developments undoubtedly will reduce it.

But with all the pioneering work that has been done, we cannot say to American industry: "Here is a coal liquefying process that will work on a particular coal. Here is the way to build a plant. Here are the plans for operating it." Such facts cannot be obtained from the equipment the Bureau of Mines has had up to the present time. I saw the little laboratory in Pittsburgh when we were holding our recent hearings. It's small—I would almost call it a toy plant. But I saw coal going in at one end and gasoline coming out at the other end. We took some of the gasoline and put it in standard-make automobiles and drove the cars through the city streets. It performed like any gasoline made from petroleum.

Other satisfactory tests were made recently of gasoline produced from coal in an experimental flight from Morgantown, West Virginia. On the first flight by an airplane in this country, using motor fuel made from American coal, I accompanied Major Arthur C. Hyde, Wing Commander of the Maryland-District of Columbia Civil Air Patrol, on the 175-mile journey to Washington D C. The motor performed perfectly on the coal-processed gasoline.

COMMERCIAL-SCALE PLANTS—Thus I believe that now is the time to conduct a vigorous research program so that methods will be available to supply necessary liquid fuels when the petroleum supply begins to fail Such data can be made available only from plants which approach commercial-scale operations These plants must be of minimum size and for the sole purpose of furnishing industry with the necessary cost and engineering data for the development of synthetic liquid fuel by private enterprise.

I have unshakable faith in the ability of our scientists and engineers to provide the best coal-liquefaction methods for American industry and American coals, but I know that the necessary answers will not be supplied overnight. Years of additional research may be required, even with commercial-scale levels. American industry cannot be asked to risk the time and money on these experiments in coal liquefaction; and since the end-result is to the advantage of all the people, it obviously is the Government's responsibility to undertake the development work to the point where industry can profitably enter.

When we are required to turn to coal and oil shale as the chief source of motor fuels in the United States we should have the processes at hand for immediate application. We certainly do not want to empty our natural petroleum reserves of every drop while waiting for satisfactory coal liquefaction methods to be developed.

⊕ ⊕ ⊕

POLYVINYL ALCOHOL

A Resin With a Bright Future

A PLASTIC so versatile that its uses vary from grease- and gas-proof coatings for paper to rubber-like molded articles and from adhesives to "sizes" for nylon and rayon will be available in large quantities for postwar applications, according to the Electrochemicals Department of E. I. du Pont de Nemours and Company.

Characterized by exceptional toughness and resistance to oil, grease, and many solvents, this plastic—polyvinyl-alcohol resin—now is employed in hose assemblies for airplanes, trucks, and tanks, oil and grease-resistant aprons and gloves for war workers, printing plates, adhesives, emulsifying agents for waxes, resins, and oils, textile "sizes." and a variety of vital military articles.

All polyvinyl alcohol today is allocated by the War Production Board for military. and certain critical civiliar needs. Polyvinyl alcohol is a membe• of the vinyl resin family, which is annually replacing 22,000 tons of crude rubber.

Polyvinyl alcohol was introduced commercially shortly before the war

started, after several years of intensive research. Military demands for it have necessitated rapid expansion of production facilities

Postwar possibilities are numerous Tough, transparent film, for example, will be available for gas and grease-proof containers, garment covers, hat boxes, and lamp shade covers Under investigation are printing rolls of polyvinyl alcohol to withstand the chemicals in new fast-drying inks, where rolls of other materials quickly deteriorate

Sheets of polyvinyl alcohol may be used for lining fuel tanks or other petroleum containers. Gaskets, washers, and molded articles of all descriptions, made of this plastic, can be immersed indefinitely in oil or most solvents without harmful effect.

As a paper adhesive it may eliminate the bother of postage stamps sticking together or of a flap adhering to the envelope before moistening. Already it has been used successfully on telegraph tape, where the layers often stick together in humid climates and ruin the rolls It is also a good adhesive for cork, cloth, pigments, ceramics, and other materials Certain war uses have shown polyvinyl-alcohol adhesives to be ideally suited for use in the fabrication of paper and paper-board boxes and cartons where strength and weather resistance are important.

Lithographic printing plates made from polyvinyl alcohol save from three to eight times their weight in critical aluminum and zinc, give approximately the same number of impressions as metal plates, and carry about 25 percent more ink without smudging These will be available for peacetime printing.

As an infinitesimally thin "size" coating on nylon, rayon, and other fibers. this plastic gives required protection to the fibers and prevents their breaking during weaving and knitting. Polyvinyl alcohol is used to make paper grease- and gas-proof, and is accordingly valuable in the manufacture of containers for such varied items as oil, food, asphalt, and paint. And it has been shown that films, obtained by dipping or spraying, will protect polished metal surfaces against tarnishing and abrasion.

Surgical sutures, photo-sensitive films, stencil screens, binders for water paints, priming coats for adhesive tape, stiffener for nylon catheters, water-soluble sewing threads, and oil-resistant thread for industry—this list indicates the wide variety of potential applications for polyvinyl alcohol.

BETTER COKE

Made With Use of Anthracite Slack

PARTIAL substitution of anthracite slack for low volatile coal will effect a saving of 225 tons of "hard-to-get" coal a day at the Rouge plant of the Ford Motor Company. In addition, tests reveal an improvement in the quality of resulting coke.

Formerly regarded as impractical for coking purposes, since coke made exclusively from anthracite slack is lacking in metallurgical structural properties, laboratory tests reveal that when it is fused in small quantities with other coal, anthracite imparts added toughness to the coke, a highly desirable feature.

SHIP TURBINES

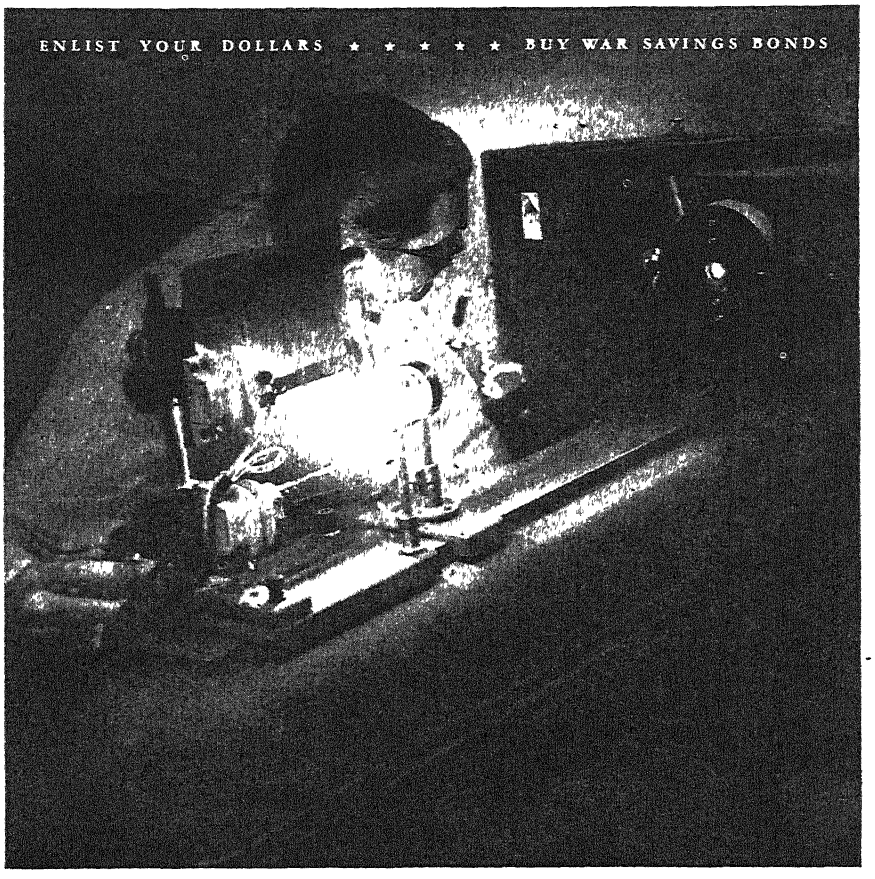
Increase Speed and Hence Capacity

PROPULSION machinery for nearly 1,000,000 tons of ocean shipping—enough to land and continuously supply two divisions of modern fighting men—was delivered from the new Westinghouse Merchant Marine plant during the first year of production, according to Ellis L. Spray, manager.

In terms of ship tonnage, he said, this represents an output nearly two and a half times as large as the plant's original promise to the Maritime Commission for performance to this date. Current production is at a rate of more than 1,000,000 horsepower a year.

Mr Spray emphasized that all production from the plant to date—about three times the number of units originally scheduled as "capacity"—has consisted of complete propulsion units. Each such unit is made up of a high and a low pressure steam turbine and a set of huge speed reducing gears to transmit the power generated by the turbines to the ship's slow-turning propeller.

He pointed out that one factor which helped to increase the horsepower output from the huge new plant was the



The Spark that Lights the Flame of Victory

A pinpoint of fighting metal placed in the arc of the spectrograph writes its own signature on a photographic plate. Inside the instrument, the light from that flame is broken up by a prism as a prism breaks up sunlight. Each element identifies itself by a series of characteristic lines, always the same for the same basic element. It reveals to the spectrographer each constituent, what impurities are present and in what quantities.

Thus spectrography helps in control and inspection. It keeps tough fighting steels tough, helps in development of new fighting metals. Spectrography is used, too, in other fields to speed research and analysis... chemicals, foodstuffs, vitamins.

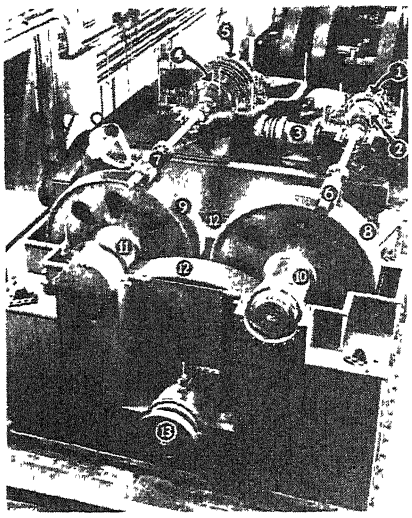
Because Bausch & Lomb had long experience with such precision optical equipment, it was ready for quantity production of gunfire control instruments, binoculars and aerial photographic lenses. When the last gun is fired, Bausch & Lomb will devote its enlarged experience to peacetime optical production.

BAUSCH & LOMB

OPTICAL CO. ROCHESTER, N. Y

Fight Infantile Paralysis January 14-31

AN AMERICAN SCIENTIFIC INSTITUTION PRODUCING OPTICAL GLASS AND INSTRUMENTS FOR MILITARY USE, EDUCATION, RESEARCH, INDUSTRY AND EYESIGHT CORRECTION



Turbines and gears of a ship propulsion unit of the type discussed in the accompanying article. Super-heated, high-pressure steam enters the far end of the high-pressure turbine (1), urged by its 400 pounds pressure and 740 degrees, Fahrenheit, temperature. Here it generates 4250 horsepower, using some 410 pounds of its original pressure and some 480 degrees of its original heat. From the exhaust (2) of the first turbine, the partially "deflated" steam passes through the connecting pipe (3) to a low-pressure unit (4) where an additional 4250 horsepower is generated. By this time the steam has lost almost all its heat and pressure and is sucked into a condenser at (5), where it returns to liquid form. Both turbines transmit their power—the high-pressure unit revolves at 5300 and the low-pressure one at 4400 revolutions per minute at full speed—to the ship's propeller—which turns at only about 100 revolutions per minute—through a train of speed-reducing gears. The small pinions (6) and (7), of different sizes to compensate for the difference in speeds of the two turbines, drive a pair of intermediate reduction gears (8) and (9) which, in turn, through other pinions (10) and 11), turn the huge "bull" gear (12). The ship's propeller is attached by a shaft directly to the center of the "bull" gear at the point (13)

change in Maritime Commission production schedules to put greatly increased emphasis on the building of Victory model cargo ships This model is a new, fast design with powerful turbine propulsion equipment to enable it to dodge subs and make approximately three times as many ocean crossings a year as the slower, less powerful Liberty ships.

The Liberty ships — powered with 2500 horsepower reciprocating steam engines which are simple and easy to produce in quantity — are "emergency" vessels designed to provide the maximum number of usable bottoms in the shortest possible time. Their low power — and consequent slow speed — are drawbacks, however, in sailing submarine infested waters, Mr Spray said Their low speed also severely limits the annual tonnage of war goods each vessel can haul by reducing the number of round-trips it can make to foreign ports.

"Each of the new, fast Victory ships for which we are now producing modern geared turbine power plants provides the cargo-carrying capacity of approximately three Liberty ships although both designs are of about equal size," he said. This is because the Victory ships are so much faster than the Liberty design.

COTTON HYDROPONICS

May Point Way to Better Material for Tires

Out of a series of gravel and water filled tanks may come a revolution in the methods of growing cotton, added prosperity for the cotton growers of America, better cotton that the world has even seen, and improved tires.

The tanks, situated in a greenhouse in Barberton, a suburb of Akron, Ohio, are part of a fundamental research program in cotton which is being carried on by The Goodyear Tire and Rubber Company. The program, which has been under way since 1937, has already resulted in much new knowledge about cotton, about the physical characteristics of cotton most desirable for the tire industry, and in the introduction of several new strains of cotton into the American Cotton Belt.

While this program is being carried on by a rubber manufacturer, it promises to benefit the entire cotton and rubber industries. Its aims are as follows

First: Co-operation with cotton breeders and state experiment stations to help them find better strains of quality producing cottons

Second: Setting up cotton variety tests at representative points across the Cotton Belt to see which varieties produce the most and best cotton under various environments.

Third Carry through a fundamental series of hydroponics experiments.

Fourth Translate the results of these hydroponics experiments into field fertilizer practices in the Cotton Belt.

Fifth Urge, by example, the growing of better cottons.

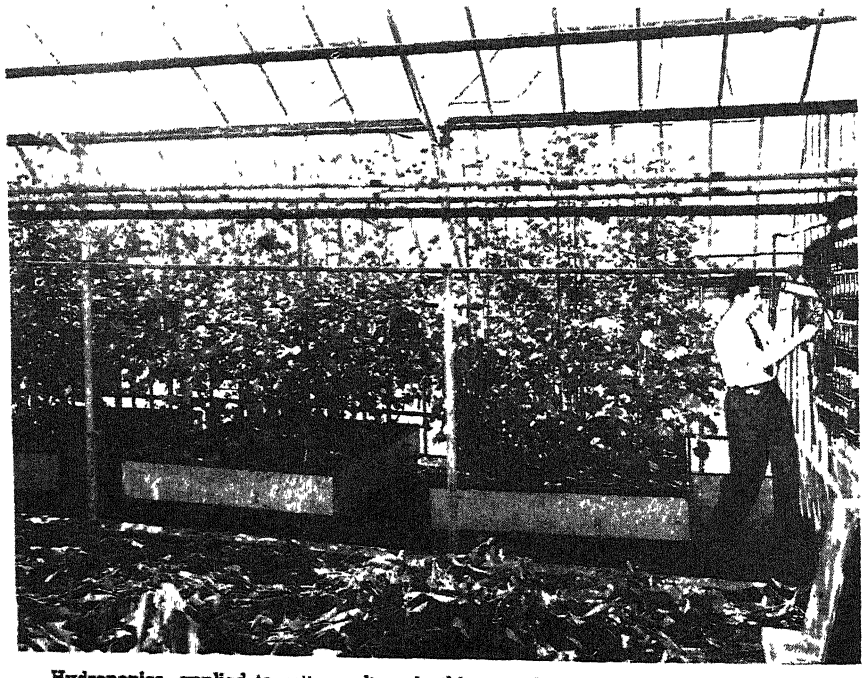
Part of the research in this program goes on in the new Goodyear Research Laboratory in Akron, part of it in the Barberton greenhouse already mentioned, the rest on cotton plantations at representative points across the entire Cotton Belt of America The researches are under the direction of Dr Burt Johnson, a member of the staff of The Goodyear Research Laboratory

It is possible that the experiments at the Barberton greenhouse will result in a revolution in methods of fertilizing cotton In these studies, Dr Johnson is seeking to find the correlation between methods of fertilizing and the resulting characteristics of the cotton lint as well as yield of the plant

Heretofore, much attention has been centered on developing new strains of cotton as a means of attaining desirable characteristics These fertilizer experiments seek to bring out fully all the best potentialities of the fibers that the cotton experts had bred into the plant

The gravel and water filled tanks already alluded to are used for experiments in so-called hydroponics or "water culture" These tanks, large, flat, shallow affairs, are in a greenhouse where temperature and humidity approach those of a cotton field.

A series of pumps at stated intervals flood the tanks with water in which fertilizers, the so-called "plant foods," are dissolved Then, in due time, the fertilizer solution runs off. The gravel merely acts as a means of support for the cotton plants growing in the tanks and furnishes no food to the cotton plants; the fertilizer solution furnishes the entire mineral nutrition for the plants Preliminary results indicate that fiber properties may be influenced by



Hydroponics, applied to cotton culture in this greenhouse, may lead to better tires

mineral nutrition and that this can be accompanied by increased yields as well.

The public may be surprised at the interest of a rubber company in an agricultural approach to cotton research but it must be remembered that the so-called rubber tire is actually a combination of rubber and fabric and the so-called cords, the strands of fabric on which the rubber is spread, are fully as important to the life and performance of the tire as the rubber

OUT-RUBBERING RUBBER

New Synthetics Offer Advantages in Manufacture and Use

A NEW material that promises to outmode natural rubber in automobile inner tubes and numerous other products has been developed in the Martin Plastics Research Laboratory, by Clayton F Ruebensaal and Earl H Sorg The new elasto-plastic, known as Marvinol, has already demonstrated its superiority to both natural and synthetic rubber for such varied applications as automobile inner tubes, elastic gloves for home, hospital, and laboratory use, and many general household and industrial uses

Marvinol is not a synthetic rubber, but a completely new material which is better suited for many of the purposes for which rubber has previously been used than rubber, itself, as well as bridging many gaps not hitherto filled by the synthetic rubbers Inner tubes, for example, can be fabricated from Marvinol more easily than from rubber, and because of the absolute impermeability of the elasto-plastic, the seepage of air through the sidewall of the tube is entirely eliminated—an accomplishment which could not be obtained with even the finest gum rubber

Most important of all from the standpoint of the tube user, however, is the fact that Marvinol is 100 percent reclaimable In cases where a tube is damaged, the motorist, instead of discarding it as a total loss, will be able to trade it in on a new tube

A second application in which the new elasto-plastic has demonstrated a marked superiority over rubber and synthetic rubber is stated to be in "rubber" gloves for surgical, laboratory, and household use. Marvinol gloves made up in the Martin laboratories have not only been tried out in actual service conditions by surgeons in hospitals, but they have been extensively tested in the chemical and industrial laboratories, where their ability to resist alkalis and acids in water solution resulted in a longevity and standard of performance unobtainable with similar gloves made from any other known material.

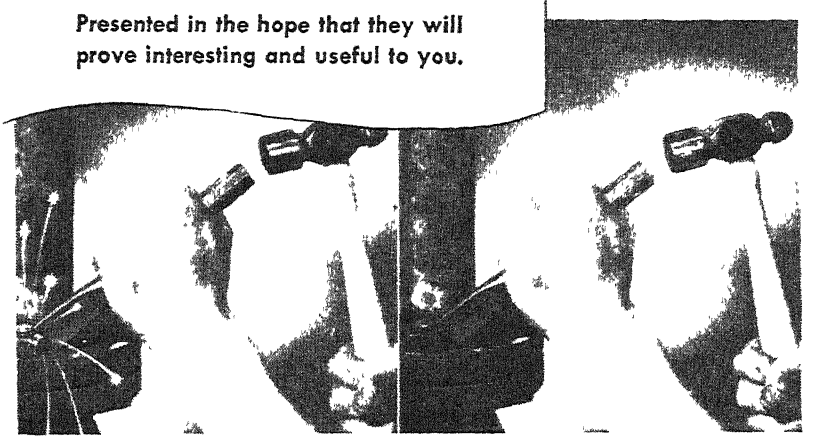
While attention so far has been concentrated on the application of Marvinol for inner tubes, gloves, and certain aircraft uses which cannot be talked about for reasons of military security, many other products that are now made only from rubber have also been duplicated. Among these have been nipples for nursing bottles, molded goods, fountain pen sacks which ink will not stain or adhere to, bulbs for eye droppers, hot water bottles, soles, heels, and even pencil erasers. Further development on these and many other products such as flexible gas and air lines, garden hose, raincoats, overshoes, and innumerable other articles, will, however, have to wait until after the war.

Marvinol is neither a synthetic rubber nor a rubber substitute, but a new material with properties all its own Actually it is a vinyl-type plastic. Like other vinyl plastics that have been developed the basic ingredients of Marvinol are coal, air, salt, and water, and the manufacturing processes involved in its production are far less complicated and expensive than those used to produce Buna and other synthetic rubbers

Furtheremore, in common with the vinyl plastics, Marvinol has properties of reclaimability due to its thermoplastic nature, superior abrasion resistance, ability to withstand constant flexing without fatigue and impermeability to gasses and liquids—properties which for years have been attracting the attention of scientists to this type of plastic as the ideal material to supersede rubber. Up to now the one stumbling block standing in the way has been the failure of vinyl materials to remain stable at high temperatures, in strong sunlight, or when in contact with even dilute acid or alkaline solutions In the case of Marvinol, however, this supposedly unsurmountable obstacle has been overcome by the inclu-

Ingenious New Technical Methods

Presented in the hope that they will prove interesting and useful to you.

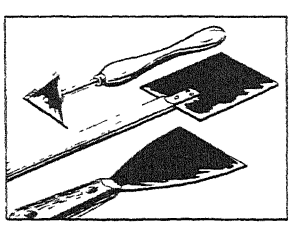


Beryllium Copper Bites Into Steel

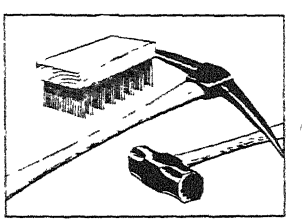
It is an old saying that when a dog bites a man it is not news, but when a man bites a dog it is news That being the case, it is certainly news when copper bites into steel Copper is, of course, one of the softer metals but when 2 percent beryllium is added to copper, its characteristics are changed The alloy is heat treatable which explains the remarkable strength and hardness Hit a chisel made of Beryllium Copper with a hammer and it will bite into steel without dulling the edge Tools made of Beryllium Copper are non-sparking and therefore are used in ordnance plants, oil refineries and other places where explosions may occur from sparks off steel tools Tensile strength as high as 200,000 lbs psi can be obtained with Beryllium Copper, hence, it is used for many applications where resistance to high loading and impact fatigue are important, such as airplane motor bushings Most of the critical springs and diaphragms used in aviation, Navy and Signal Corps instruments are made of Beryllium Copper because of its reliability as a spring material

We hope this has proved interesting and useful to you just as Wrigley's Spearmint Gum is proving useful to millions of people working everywhere for victory

You can get complete information about this process from the Beryllium Corporation, Reading, Pennsylvania



Man has tried for ages to rediscover the art of hardening copper Today this can be done by adding to copper a small percentage of beryllium



Not only does it produce an alloy harder than tempered steel, but one that does not produce sparks, an essential when working near highly combustible materials.

TURN YOUR
IDEAS
INTO
MONEY

SUGGESTIONS WANTED FOR PRODUCTS THIS PLANT CAN MAKE

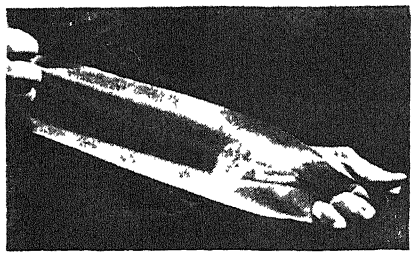
Our enlarged facilities for precision manufacturing, now engaged 100% on war work, can be readily converted to peacetime products when victory is won.

If you have suggestions for postwar products, write us describing your invention. We are particularly interested in the following types of products — toys and games, electrical devices, auto accessories, household items, including metal furniture, kitchen utensils and toilet articles.

YOUR RIGHTS WILL BE FULLY PROTECTED

Send us a description of your invention but *do not* send finished drawings until they are requested. Our engineers will examine carefully all ideas. If yours are acceptable, an offer will be made for either an outright purchase or use on a royalty basis that is mutually satisfactory. *Write Post War Planning Committee Department 2SA.*

ARNOLT MOTOR COMPANY
Warsaw, Indiana
Peacetime Builders of
SEA-MITE
Marine Engines



Compar flexes even at low temperatures

sion of a sealed-in, non-extractable plasticizer in the compound. Air, water, sunlight, acid and alkaline solutions, and temperatures up to 250 degrees, Fahrenheit, do not have any effect on this plasticizer, and as a result the compound retains its elasticity, resiliency, and flexibility just as pure gum rubber does, with the added advantage that Marvinol does not have rubber's tendency to oxidize or age.

The new material can be processed on standard rubber working machinery. Marvinol stocks can be compounded and mixed on a regular open rubber mill, and extruded, molded, and calendered on the same machines used to extrude, mold, and calender regular natural rubbers. The sole exception is the fact that with Marvinol the vulcanization process, or heat treating and compounding with sulfur, is completely eliminated.

Another name to add to this same list of synthetic plastics is "compar"—a group of coal-limestone-and-air derivatives which might be called the missing link between plastics and synthetic rubber—notable for unparalleled immunity to the new hard-to-handle aviation "super-fuels." The development of an almost endless chain of compar variations, announced recently by Resistoflex Corporation, grew out of the demand by warplane designers for a flexible material to handle toluol, xylol, and benzol—which give the new United States super-gasolines their tremendous power but which quickly destroy most organic materials.

The compars are described by Resistoflex officials as "transparent, flexible, rubber-like plastic materials, 5 to 20 times more wear-resistant than natural rubber, and the most solvent-proof rubber substitute yet developed."

RUGGED PACKAGES

Needed for Preservation of Dehydrated Foods

THE NEED for rugged packaging materials for dehydrated vegetables, that will stand up not only under severe laboratory tests but will also meet the demands of actual performance, is stressed by Dr. J. R. Sanborn and Dr. G. J. Hucker of the New York State Experiment Station. The scientists have studied over 150 different materials for such purposes. When a long series of tests, increasing in severity, were applied, less than five of the materials showed sufficient resistance to warrant their inclusion in the final trials on bulk-packaging of dehydrated vegetables.

"The proper preservation of dehydrated foods is not simple nor can it be readily attained by providing elaborate packages," say the Station scientists. "While development of suitable packages is necessary as a means of insuring adequate protection of the contents under severe conditions of handling and storage, careful consideration of the requirements of the foods themselves is basically important Past neglect of this approach, even in years of 'peace and plenty,' left us destitute of a reliable working basis with which to meet the demands of wartime emergencies satisfactorily and promptly."

Sufficient ruggedness to withstand impact and tumbling, particularly at low temperatures, is the specification most difficult to meet in the case of most packaging materials, it is said Resistance to the deleterious effects of high and low temperatures and to moisture permeability at high humidity levels and when submersed are other "musts" of a suitable material for packaging bulk dehydrated vegetables.

PROPELLER CHECKING

Done by Automatic X-Ray Equipment

A NEW "studio" fitted with one of the most powerful X-ray machines in the aviation industry is speeding-up the process checking of hollow steel propeller blades for combat aircraft by taking "pictures" of three entire blades simultaneously.

Since this 400,000-volt X-ray unit has gone into service at the American Propeller Corporation, it has been possible to secure the required nine negatives of three blades (three for each blade) in the same time formerly required for one negative, with the same crew doing the job. The crew consists of four women, whose work is further facilitated by the fact that delivery of the blades to the "studio," taking of the exposures, and removal of the blades from the X-ray room are entirely automatic.

The blades, X-rayed after the fillets have been brazed in order to check on the work up to that point, are received in trucks at the X-ray laboratory and placed in groups of three on special cars that run on a roughly oval track. Just

X-ray studio for propellers

outside the door to the "studio," the women operators put X-ray plates in position—there are three such plates to each blade—and place the various pieces of metal that are used for identification and to indicate on the finished negative the intensity of the X-ray penetration.

When all is ready, a button is pushed on the control panel and the heavy door in the side wall of the lead-lined chamber rises. As it reaches the end of its travel the door trips a relay that starts the motors that draw the blade-loaded car into the chamber. This car trips another relay as it passes a given point and the door closes behind it The car stops in position under the X-ray unit which is set at a predetermined distance, vertically from the car The exposure is made automatically. As the X-ray machine is shut off, a relay starts the mechanism that raises another door in the farther wall. As this door reaches the end of its travel, it causes a motor to draw the car, laden with the now X-rayed propellers, to the outside of the chamber, and the door slides shut.

The car is pushed manually to a convenient point and unloaded. In the meantime, the women operators have made another car ready to go through the process. The X-ray plates are developed quickly and are studied by women inspectors. No further work is done on a blade until it has passed this inspection. This is the second of three X-rays made of each blade, the first being an X-ray of the resistance weld of the small section of blade tip and trailing edge that has to be welded, and the third being of the tip near the completion of the manufacturing process

AIRCRAFT HEATER

Operates at Extremes of Temperature and Pressure

SAID BY aeronautical engineers to be the only high-altitude combustion type airplane heater that meets every requirement of modern aviation, a new type of aircraft heater lights and burns almost instantly at any temperature down to 70 degrees below zero, Fahrenheit, and at any altitude up to 57,000 feet in simulated pressure chamber. Its major purposes are to de-fog, de-ice, and anti-ice windshields, gunners' side windows, and turrets, to prevent ice from forming on wings and empennage surfaces, to keep bombsights clear, and to keep instruments, gun breeches, and other equipment operative—even to keep the crew alive.

Difficulties in the way of designing this heater, known as the Surface Combustion "Janitrol," included: The air at 30,000 feet is so thin that a candle will not burn because there is insufficient oxygen; to support combustion, a surplus of air must be mixed with the fuel, as in the cylinder of a supercharged engine. Other problems encountered were: The necessity of operation at both high levels and at ground level; the capability of being lighted at 70 degrees below zero; ability to stay lit in a long dive when the air pressure suddenly increases and may build up to ten times the pressure encountered before the dive starts; assurance of sustained operation regardless of any angle which the plane may take or altitude to which it may climb.

Although the heater usually operates from the air supplied by the motion of the plane, an auxiliary blower can be installed for use in flight and for service when the plane is on the ground.

The principle of operation engineered into the design of the Surface Combustion "Janitrol" aircraft heater has proved to be the simplest and most efficient for this type of service. This unit uses liquid fuel, generally high octane gasoline. It operates equally well, with minor modifications, on lower octane gasolines and other liquid fuels.

The heater operates on the principle of burning a vaporized or atomized fuel in the center of a column of spinning air. The whirling action of the combustion air is produced by introducing the air into the cylindrical combustion tube tangentially to its inner surface.

The liquid fuel enters the combustion tube through a vaporizer or spray nozzle ahead of the combustion air inlet. This vaporized or atomized fuel is mixed with the spinning column of air, forming a long, tapering core of enriched gases completely surrounded by the whirling air column. The combustion process is thus prolonged or delayed for maximum efficiency and heat liberation throughout the full length of the combustion tube. Since the fuel and air are mixed within the heater, its operation is independent of additional mechanical devices.

The resulting flame is stable and sus-

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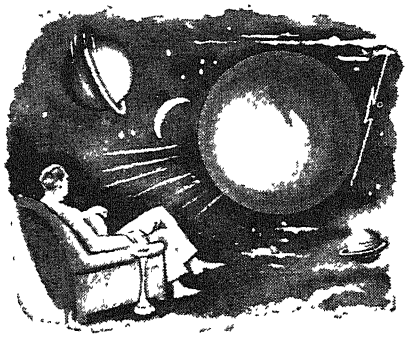

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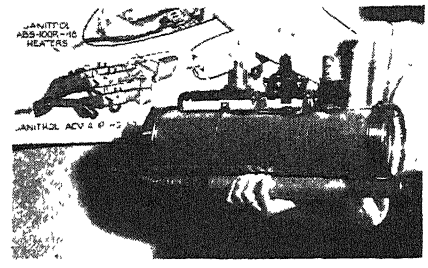
tains combustion under the most adverse conditions The long luminous "whirl flame" is swirled around itself many times; thus re-ignition is continuous and the combustion process is "self-piloting" There is no "blowing



New light-weight aircraft heater

off" of the flame as experienced on the conventional burner system when greater volumes of air are admitted

The annulus or blanket of hot combustion air which surrounds the flame core not only provides an adequate supply of oxygen but actually scrubs the inside surface of the combustion tube and prevents direct flame impingement on the inner metal surface. At the same time, it effectively minimizes the accumulation of carbon, lead salts, or any other combustion products on heating surfaces

RAYON TANKS

Save Weight in Fighting Planes

MANY FLIERS' lives have been saved in this war because their planes were equipped with bullet-sealing gasoline tanks made of a rayon fabric coated with rubber. Rayon is used in the self-sealing tanks primarily because it provides the required strength and tear or bursting resistance together with the light weight needed for use in fighting planes. Expressed more technically, rayon fabrics can be made with a strength-weight ratio that is greater than that of many other fabrics. Every pound saved in the permanent equipment of a plane may be applied to provide heavier armament, a larger supply of ammunition, greater gasoline capacity, or higher horsepower.

NAVAL STORES

Conservation Program Being Carried On

CONTINUATION of naval stores conservation as a part of the general program for the conservation and use of agricultural and resources has been approved by the War Food Administration.

Objectives of the 1944 program are conservation of timber resources and prevention of their non-economic use and wasteful exploitation through the adoption of approved turpentining practices, including better fire protection and better cutting practices. Voluntary participation in the program is open to gum naval stores (turpentine and rosin) farmers in North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas. Payments may be earned by working only the larger trees and protecting the growth of pines by accepted conservation methods. Since both gum turpentine and gum rosin are recognized as strategic war materials, the new program contains no limitation on maximum production consistent with the preservation of the productiveness of existing resources

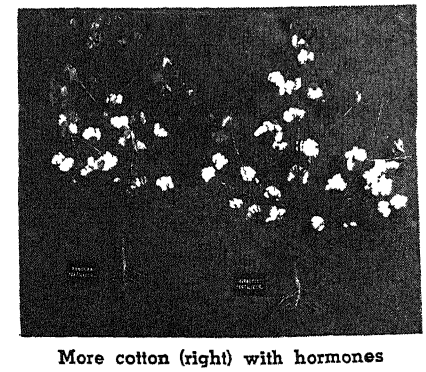
Protective measures include the provision that producers do not work trees under nine inches in diameter and that only one face be worked during the 1944 season on trees less than 14 inches in diameter at breast height No payment will be made for faces measuring more than 90 inches in height at the beginning of the 1944 season The program utilizes practices based upon research and experiments carried on for years by the Forest Service, Bureau of Agricultural and Industrial Chemistry, and other Department of Agriculture agencies

BEATING THE BOLL WEEVIL

Early Maturity of Cotton Seems To be One Answer

THE BOLL weevil is the most important limiting factor in cotton production, its ravages have cost the cotton growers of the South untold millions Hot, dry summers seem to be its most effective control, while wet summers aid its rapid development But if "safe" bolls can be set ahead of the multiplication of the weevil—between the latter part of July and the first part of August—control can be greatly assisted

Research and experience have shown that early planting of cotton seed of early maturing varieties, accompanied by early poisoning, have greatly helped in this race Another factor which bids fair to play an important part in this speeding-up process is the use of plant hormones stabilized in the fertilizer Such a combination, known as Hormo-



More cotton (right) with hormones

Fert, has been reported previously in the November 1941 and November 1943 issues of Scientific American.

This special fertilizer, due to its rapid action in promoting root formation, advances maturity of cotton squares, blooms, and bolls, bringing them to this point ahead of the ravages of the boll weevil.

Using Hormo-Fert in many test plots, together with the planting of a number of cotton crops extending over several years, it has been possible to

secure, on both test plots and crops ten days earlier cotton with a greater yield as compared with results using the same fertilizer without hormones.

In normal years with practically no boll weevil damage, test plots have shown 10 to 12 percent increase in yield of seed cotton. In 1943, a bad boll weevil year, tests conducted by D. J. Murray, Assistant County Agent of Wayne County, showed double this increase with Hormo-Fert.

Comparing the planting on farms of approximately 400 acres, in Wayne County, North Carolina, for the years 1939 and 1940, two years before using the special fertilizer, with the years 1941 and 1942, two years after using Hormo-Fert, there was an average increase of lint cotton per acre of 53 pounds, or just a little over 12 percent In 1943, a total of 519 acres of cotton was planted using Hormo-Fert at the rate of about 650 to 700 pounds per acre. An average of 510 pounds of lint cotton was obtained per acre, or 530 five-hundred-pound bales on the total acreage. This is a significant result when contrasted with the county estimate of 325 pounds per acre.

The extra cost per acre of Hormo-Fert over regular fertilizer, using 600 to 800 pounds per acre—usually a desirable amount—is 75 cents to $1, with a probable net return of $12 per acre during a normal season, or approximately $25 to $30 during a bad boll weevil year— *Lionel Weil.*

SYNTHETIC RUBBER

Can Render Natural Rubber Supplies Immaterial

THE SUPPLY of natural rubber is not coming back quickly, if at all, in the opinion of Dr. John T. Blake, chief chemist of the Simplex Wire and Cable Company. In an address before the American Chemical Society, he had this to say

"Synthetic rubber must be developed to the point where the restoration of natural rubber is a matter of indifference. I have confidence that this can and will be done.

"Shortly we shall have available as much [synthetic] as is needed for war and essential civilian purposes The rubber industry is now substantially converted to its use, although synthetic rubber is not all that we might wish it to be when we use it in the production of useful articles However, we are manufacturing from it things that are serviceable.

"Ordinary tires, insulated wire, and other items are capable They will work. They insure that our civilian economy will not collapse and that we can keep our Army and Navy fighting.

"Three years ago the rubber industry had to a large extent reached an equilibrium. The big accomplishments had already been completed. Acceleration, antioxidents, reinforcing agencies, and other developments had obtained substantially their full stature. Advances in sight were of degree only, and of small degree at that.

"Our work on synthetic rubber has changed all this. To use but one illustration, vulcanization, the key process of the rubber industry, was a unique phenomenon applying only to rubber and sulfur. A host of synthetic materials can now be vulcanized with a wide variety of reagents, and these new facts must lead to a better understanding of this particular process In other sections parallel discoveries have been made."

GREY IRON

Has Outstanding Advantages in Many Applications

ONE PROPERTY in which grey cast iron has an inherent advtantage is torsional strength In steels, the ultimate strength in torsion is lower than the ultimate tensile strength, but with cast iron, the situation is reversed, the torsional value being 25 percent to 40 percent higher than that in tension. Thus it is evident that our modern high-strength alloy irons will develop torsional strengths superior to those of the common structural steels, and are, therefore, highly suitable for applications in which the chief stresses encountered are in torsion, such as flanged couplings, pulleys, and so on.

This is true also of such parts as crankshafts, which are subjected, in addition, to periodic vibrational impulses The ability of grey iron to dampen out vibrations has long been recognized, and is attributable to its discontinuity of structure, the graphite inclusions preventing such impulses from being built up to the danger point, which can easily occur with a more homogeneous material such as steel

For some years prior to the war high strength grey irons alloyed with nickel chromium, and molybdenum, were coming into progressively broader use for crankshafts and camshafts in heavy Diesel engines, pumps, compressors and certain types of small gasoline engines. The adoption of the high strength alloy irons for these purposes was due to their good torsional properties, combined with damping capacity, notch-

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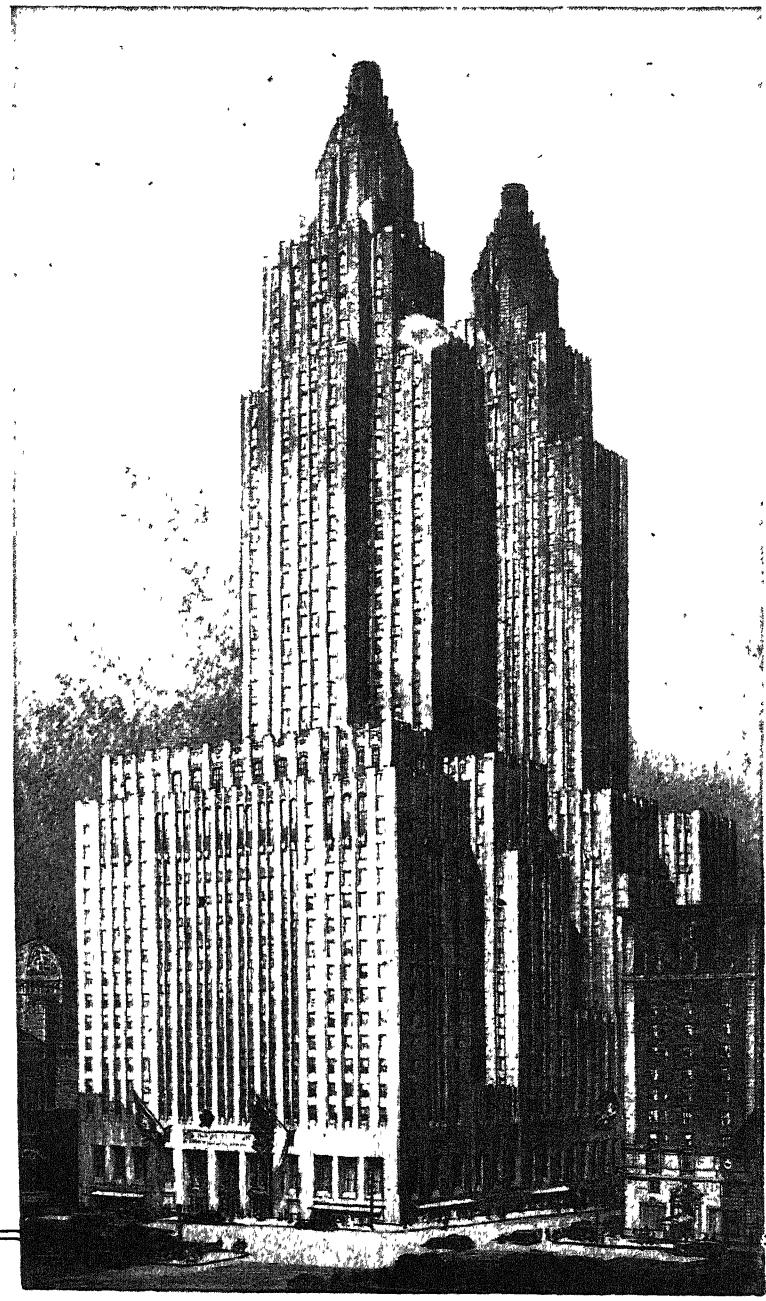

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sensitivity, and high wear-resistance on the bearing surfaces. Moreover, the economic advantage of a cast material, in cases where the quantity to be produced is comparatively small and expensive forging dies can be eliminated, is obvious.

For these reasons, crankshafts of alloyed grey iron are in use to a considerable extent today in engines operating on war production and war transportation, and resumption of unrestricted civilian production in the post-war period should result in a tremendously increased adoption of this material for such applications—*Nickel Cast Iron News.*

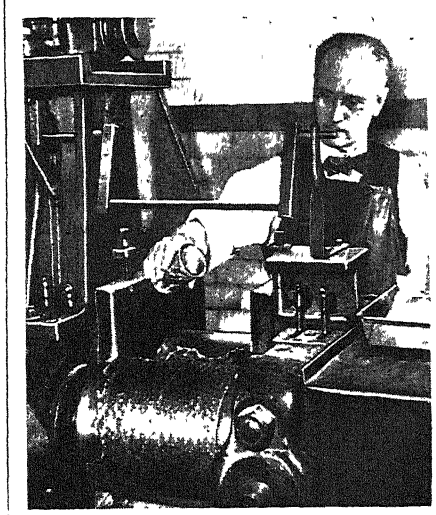
USKOL

Not for Tires, but for

Many Other Rubber Applications

A NEW synthetic rubber, the sixth major type to be discovered through chemical research, has been developed by the General Laboratories of United States Rubber Company, according to Herbert E. Smith, president.

"Known as Uskol, this new synthetic will be used in both industrial and



Compounding Uskol in the laboratory

household products," Mr. Smith says "As a result of its distinctive properties, it is expected to take its place alongside the present five commercial types of synthetic rubber—buna S, buna N, neoprene, butyl, and thiokol

"Offering a new high degree of resistance to solvents, this new synthetic will be used in the manufacture of commodities which come into contact with fuels, oils, gasoline, dry cleaning fluids, and other penetrating chemicals which are the enemies not only of natural rubber but of the other five synthetic types. It will also be used for specialties such as industrial molded items, tubing, gas and oil hoses, tank linings, and for application to paper and cardboard to render them resistant to grease, water, and chemicals.

"Household goods such as mats, dish drainers, sink strainers, aprons, gloves, and the like, may be made from the new rubber. It also may make possible for the first time the manufacture of raincoats that can be dry cleaned. It is not applicable to tires but it can replace

n various items other synthetics which can be used in tires."

In addition to its superior resistance to solvents, Uskol is said to possess numerous other advantages, including the following It can be vulcanized in several ways to acquire high physical properties, it has high tear resistance exceeding that of natural rubber; it can be used alone or as a blend with other synthetics; it is more resistant to the effects of sunlight, ozone, and oxygen than any other synthetic rubber; it has no odor either in the raw material state or in the finished product; it can be produced with present machinery and it is easy to handle during manufacture.

This new synthetic resulted from search for a rubber which would provide greater resistance to attack of high octane gasoline Its use will be limited to war products for the duration.

PISTON MACHINING

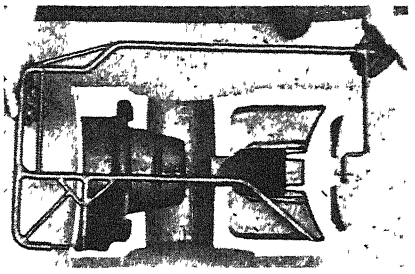
Simplified by Use of Ingenious Jig

A VALUABLE contribution to engine production at the Cooper-Bessemer plants consists of a simple jig devised to save time and to overcome the difficult problem of producing engine pistons with consistently uniform wall thicknesses.

Developed by John V. Shaffer, Cooper-Bessemer machinist, this tool was constructed of several pieces of tubing welded together in the form shown in the accompanying photograph.

The end of the jig is inserted through the narrow opening at the bottom of the piston core so that it contacts the wall inside the cored chamber. By revolving the jig around the outside circumference of the piston, and inscribing marks at intervals by means of a sharp pin in the outside end of the jig, the true center of the casting is designated at the point where the inscribed lines intersect.

The lathe operator is thus able to save a considerable amount of machining time and produce a piston with an outside diameter that is concentric with the inside core, resulting in absolutely uniform wall thicknesses so desirable in oil-cooled piston design.



Simple jig for checking pistons, shown in place in sectioned unit

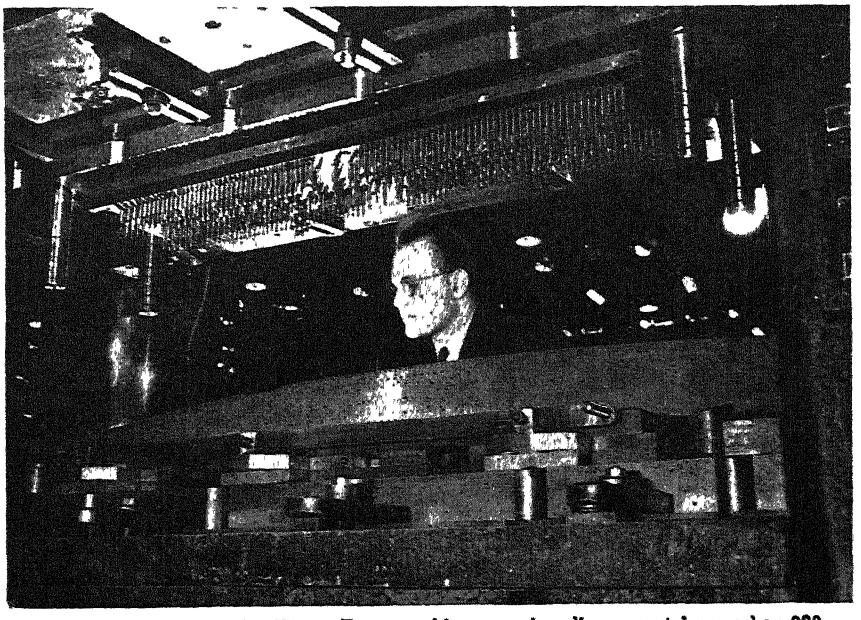
PORCUPINE DIE

Punches Hundreds of Holes In a Single Stroke

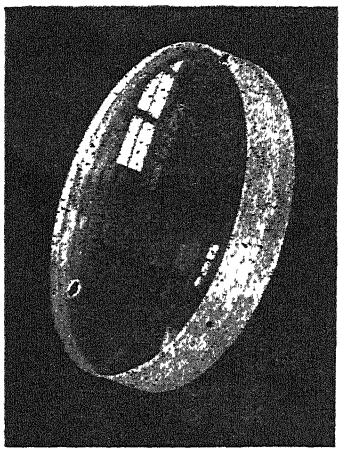
CAPABLE of punching 388 riveting holes in a single stroke of a giant hydraulic press, a new Boeing-developed die is turning out parts, ready for riveting, 30 times faster than the previous method of drilling. Parts manufactured by the new die are riveted together to form the bomb-bay catwalk of the Boeing Flying Fortress.

Tool engineers express the belief that this die contains the largest number of coördinated punches ever to be located in a single die. Affectionately named the "Porcupine" by Boeing employees, because of the similarity between the many punches and a porcupine's quills, the new die makes a total of 976 riveting holes in ten separate parts which comprise the walkway through the bomb bay of the big bomber. These are assembled, as a sub-assembly operation, with more than 400 rivets. Aside from the web, or flooring, which is aluminum .064 inches thick, four "T" sections as well as angles and reinforcements are pierced on the porcupine. The heaviest material is .150 inches thick—over an eighth of an inch.

The construction of the porcupine was



At Boeing's home of the Flying Fortress, this porcupine die accurately punches 388 holes in a single press operation. This is 30 times faster than by previous methods



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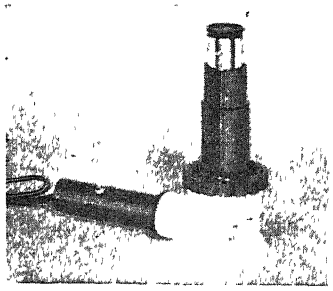

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held to an accuracy of 5/10000 inch This insures alinement of holes from one part to another, making possible rapid assembly and greater production A die of this type is expensive to manufacture Its construction, however, typifies the quantity production tooling which is continuing to alleviate the manpower shortage

DRUG SOURCES

Now Assured to the United States

AMERICA in peace or war has declared its independence of foreign sources for its vital drugs— from digitalis to quinine—"an investment which must never be forsaken," according to Dr. Ivor Griffith, president of the American Pharmaceutical Association.

"Consider how great was our need for quinine, a distinctly vegetable compound which over the decades has resisted all efforts dedicated to duplication," says Dr. Griffith. "Bataan and Corregidor might have had totally different implications had a supply of this vital botanical derivative been available at the critical time And what a marvelous job has been done in this country even in the course of the last two or three years in making available natural plant drugs which in normal times had been imported in great amounts: Digitalis, the outstanding heart drug; belladonna, the source of the important atropine and other important principles; valerian, hyoscyamus, squill, aconite, and other drugs, once could be secured only from Europe or elsewhere on foreign soil.

"Indeed, in a land where cardiac diseases are high in the death-dealing scale, does it not seem strange that digitalis and strophanthus and squill and other heart-active drugs had to come from Europe or elsewhere? And every time Europe had a fuss of its own the great American heart went begging for its proper medicine."

The declaration of independence from these sources just signed by America was "commonplace insurance," Dr. Griffith says, adding·

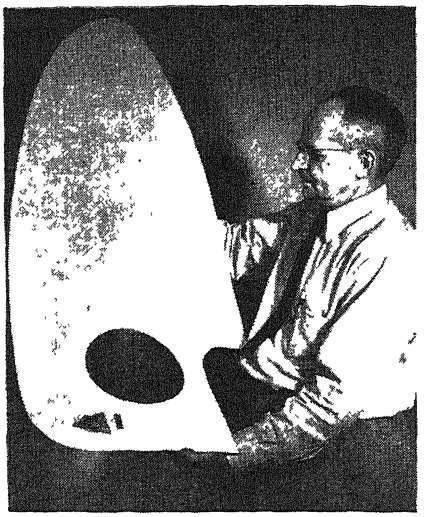
"The day may yet come when science, kept pure, will bring to the world the gift of permanent peace Who wants Java except for her rubber and quinine? When rubber and quinine are made in the shop, then Java will not be such a bone of contention."

PLASTIC BOARD

Light in Weight, Easily Formed

ONE OF the uses of plastics with a future is the development of a plastic board that is already in wide war use and for which engineers are perfecting important peacetime uses that should greatly lighten the work of housewives and add beauty and color to the home.

The plastic board is very light—only half the weight of aluminum. Its tensile strength and its ability to withstand strains compare favorably with best metal alloys with relation to weight,



New light-weight, strong plastic board, described below, is used for forms that support bullet-sealing fuel cells in military airplanes

according to United States Rubber Company engineers It is also a nonconductor of electricity, will stand excessive vibration and is not affected by gasoline, oils, aromatic blends of fuels, acids, most alkalis, alcohol, and other solvents. The fact that it retains its properties over a wide range of temperatures makes it highly useful for wartime needs.

The plastic board can be bent, cut. and formed into almost limitless shapes These and other properties give it great promise for a wide variety of uses in the home, on the farm, and in industry after the war

WHAT IS ELECTRICITY?

Adequate Answer Requires Volumes

OFTEN asked of the scientists in General Electric's Research Laboratory is the question "What is electricity?" L. A. Hawkins, executive engineer of the laboratory, has one answer, although he says that whether an answer is possible depends on the kind of definition desired.

"For instance, the question 'What is water?' may be answered in three different ways," explains Mr. Hawkins. "First, we may define water by its composition; second, by its source or occurrence, and third, by its properties—its boiling and freezing points, its density, its action as a solvent, its part in maintaining life, and so on.

"But when we come to electricity, we find only one kind of definition is possible, because electricity is the most fundamental thing in the universe and is the thing of which everything else is made. Electricity cannot be defined by its composition, for it is composed only of itself. Neither can it be defined by its source or occurrence, for it is everywhere, wherever there is matter or radiant energy.

"Therefore, electricity can be defined only in the third way, by its properties —and to describe these properties adequately requires a book or several books."

New Products

RESURFACING COMPOUND

To REPAIR or completely resurface broken or worn floors, driveways, ramps, and so on, a concrete-like compound is now available in ready-mixed form for quick and easy use To resurface and level an entire floor or roof area overnight, or to transform an old wooden floor into a smooth but skid-proof, spark-proof, and fire-proof surface, Lev-L-Flor may be applied by unskilled labor. This product has greater compressive strength than concrete, though much lighter in weight Because it is more resilient than concrete, it will not chip or crack under hard traffic and for the same reason is less tiring and easier on the feet.

Tests of this compound show that it does nine jobs in one application—repairs, resurfaces, water-proofs, dust-proofs, acid-proofs, damp-proofs, slip-proofs, decay-proofs, and weather-proofs.

NEW KELVIN BRIDGE

SEVERAL innovations are presented in a new model Kelvin bridge just announced by Industrial Instruments, Inc. First, the bridge source voltage is 60 cycle A.C. instead of the usual D C. Second, an electron-ray null indicator has been substituted for the conventional galvanometer Third, the instrument can be operated by unskilled personnel at high speeds—up to several hundred tests per hour with suitable test fixtures Fourth, the entire equipment is completely self-contained in a single cabinet, requiring no outside accessories such as batteries or galvanometers Fifth, operation is reduced to utmost simplicity and directness, since measurements are obtained by the rotation of a single dial directly calibrated in resistance, the dial readings being multiplied by a factor determined from the setting of the standard resistance switch.

The new Model K-1 bridge is particularly useful for routine measurements in production, or in the laboratory, on low-resistance elements such as fuses, fuse clips, switch contacts, wire, bonds, and other similar items

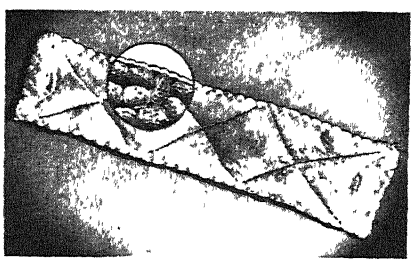
Bridge for shop or laboratory

QUENCH TEMPERING

TOOL STEELS dipped for quenching into a new liquid material known as Steeltemp are simultaneously tempered, thus eliminating one operation This material is applicable to chisels, taps, punches, star drills, and similar tools.

PROTECTION PADDING

LINING of a new type for goggles, chin straps, sweat bands, and other headgear has been developed which incorporates the use of sponge clippings and chamois skins. The soft texture of chamois skins and the natural resilient characteristic of sponge clippings combine to make an ideal protection padding.



Sponge clippings in chamois pad

Among the many uses for this new development is padding for head phones Operators of listening posts have found that perspiration is a constant source of chafing to the head-phone wearer But with this new sponge and chamois padding inserted in the inner section of the ear phone unit, all perspiration is absorbed and soreness due to chafing is eliminated.

In war plants, perspiration running down the faces of workmen can be a threat to war production To eliminate this threat a sponge and chamois sweat band has been produced which eradicates the danger of sweat getting into the workman's eyes

LOCK-TYPE PROTRACTOR

A NEW pocket-size, lock-type protractor is designed for accurately measuring angles of drill points, tool bits, machine ways, and depths of deep holes, for sketching and laying out tool and machine parts, dies, and jigs, and for inspection of manufactured parts.

Made of fine materials and vernier equipped, Xactor's adjustable lock-type sliding scale pivots 360 degrees, assuring measurement of any angle instantly to an accuracy of $\frac{1}{2}$ of 1 degree Deeply etched graduations afford easy readability.

Aside from its accuracy, this new protractor has the added advantage of

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Diameter	F L.	Price
53 MMS	7"	$1.50
55 MMS	6"	1.50
36 MMS	4"	1.30

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Cemented Achromats

Diameter 10 MMS F L 33 MMS 80¢ each—two for $1.50

Flint Optical Glass Plano-Concave Lenses

Use for reducing glass, supplementary camera lenses experiments etc

Diameter	F L	Price
43 MMS	—127 MMS	only 50¢
45 MMS	—460 MMS	only 40¢
60 MMS	—99 MMS	only 70¢

Crown Optical Glass—Double-Convex or Unsymmetrical Biconvex Use for magnifiers, gadgets, experiments, etc

Diameter	F L	Price
36 MMS	46 MMS	only 70¢
60 MMS	112 MMS	only 60¢
75 MMS	173 MMS	only $1.25

Pocket Microscope Set

Make a little microscope to carry in your pocket etc
Eye-piece lens 14 MMS Dia . 39 MMS F L
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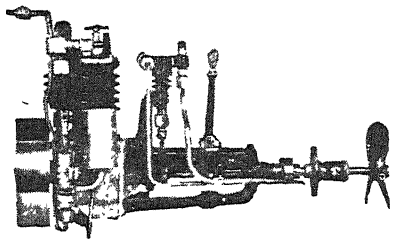

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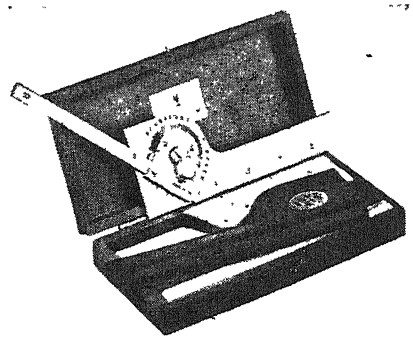


Versatile vernier-equipped protractor

a quick acting and compact locking feature on the vernier turret which rigidly secures any specific measurement or angle by locking both the vernier turret and the sliding scale. This enables accurate mass gaging necessary when many items of the same size or angle must be checked

DIAMOND-BONDED WHEEL

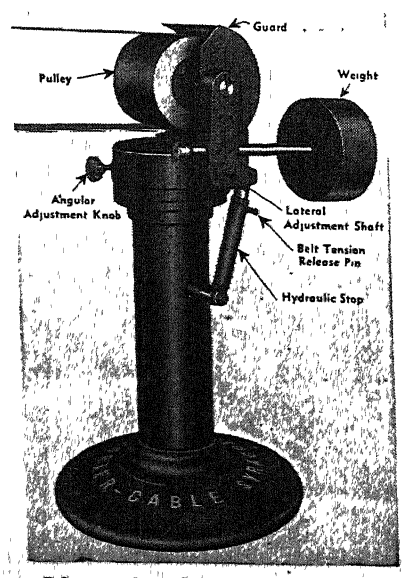
NEWCOMER in the field of diamond-bonded wheels is the Super-Cut, just announced by Industrial Abrasives, Inc. A secret bonding process reportedly gives to Super-Cut diamond wheels an unusually long life, as shown by numerous tests. The new bonding process sets each individual diamond solidly and uniformly in a special metal, thus giving both fast cutting and long life

Super-Cut wheels are made in a wide variety of types and sizes, making them adaptable to hundreds of tool and grinding operations.

BACKSTAND IDLER

A NEW addition to a line of abrasive belt grinders is the Porter-Cable backstand idler shown in the accompanying illustration. This idler is used to adapt grinding and polishing lathes to abrasive belt grinding.

The backstand idler makes possible the use of an endless metal-cutting abrasive belt, which is faster cutting than coated polishing or solid "stone" wheels. Then, too, heat is reduced because of the long abrasive belt used This lower temperature operation greatly decreases such hazards as heat discoloration, warping, fracturing, and so on.



Adapter for abrasive-belt grinding

Where it has been customary to grind, rough polish, and finish on regular wheels, the same results are obtained by the abrasive belt method, but the rough polishing operation can be eliminated.

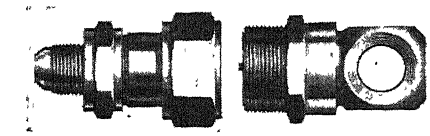
PORCELAIN-CLAD CAPACITORS

FOR HIGH-VOLTAGE D C. applications where space is limited, new porcelain-clad capacitors are hermetically sealed in a tubular, wet-process porcelain body with solder sealed end closures. The end closures act as the capacitor terminals by connecting the element leads at opposite ends, utilizing the porcelain tube as insulation.

By eliminating the large metal case and bushings required by metal-case capacitors, the new Westinghouse porcelain-clad capacitors help maintain minimum over-all dimensions. Larger types are furnished with or without cast mounting flanges. Where castings are used, the capacitors are solder-sealed, then castings are cemented on with a mineral-lead compound.

SELF-SEALING COUPLING

A DISCONNECTING self-sealing coupling, said to withstand a pressure of 2500 pounds per square inch after just ordinary finger-tightening, is a development of American Screw Products. Tests show that the heavy construction of the aluminum alloy body prevents



Leak-proof self-sealing coupling

distortion, and that jamming of the spring-loaded shut-off valve is prevented. One sample coupling was purposely crush-tightened with a long-handled wrench yet is reported to show no leakage upon disconnection and reassembly.

Springs are of heat-treated steel. Lightweight cast phenolic poppets are positive-sealing in action. The synthetic gasket provides leakproof connection when coupled for service.

WALL PROTECTION

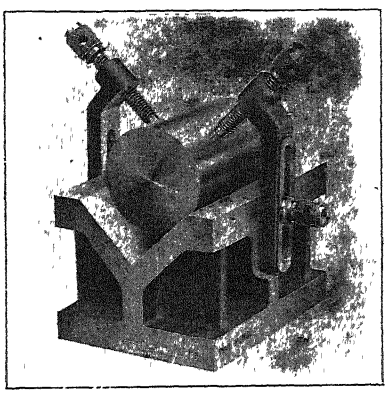
MASONRY walls are subjected to disintegration due to low and high temperatures and high and low moisture content. The usual method of protection has been a paint coating made up of oils or resin emulsions, casein, or cement, mechanically bonded to the surface.

A new product from the A. C Horn Laboratories, called Waterfoil, has now been developed using an entirely different principle. Waterfoil is made of irreversible inorganic gels. The lime hydrate of the masonry reacts with the

inorganic gels to form an "irreversible" protective coating of microscopic "spongelike" character. When applied to masonry, such as brick, concrete, or stucco, Waterfoil welds itself to the surface not only mechanically but chemically as well. Water vapor finds exit, but actual water penetration is impeded, thus helping to prevent reinforcing bar rust and concrete spalling.

IMPROVED "V" BLOCK

WITH A ribbed base of cast iron, to which are fastened forged steel facings to form the "V", the device illustrated in this column is known as the Hercules



"V"-block facings can be refinished

Heavy Duty "V" Drill Block The facings of the block, as well as the clamp bars, are accurately machined and heat treated. When the facings wear, they may be readily removed for re-finishing, thus prolonging their useful life.

BIN-LEVEL INDICATOR

OPERATING by electronic principles, a dry materials bin-level indicator is wholly foolproof because there are no moving parts to wear or get out of order. For the same reason, danger of clogging, arcing, and mechanical breakdown is eliminated and the device is effective in measuring all types of material, whether fine or coarse.

Use of the bin-level indicator, made by Mosher Electronic Control Systems, gives a positive check on shipping and storage operations and thereby prevents possible loss of valuable material through spillovers, underfills, or other miscalculations.

The device consists of two parts. The first is a detector box, which is attached to a probe extending into the bin. In the box are a series of vacuum tubes. A second box is the signal control which is attached to a series of colored lights that show conditions in the bin. Hookup with valve cut-offs, sound makers, or remote signal devices can readily be arranged through appropriate relays.

BORING TOOL

A RADICALLY different type of boring tool that is reported to get diamond boring machine results from an ordinary lathe is called the Shearcutter Boring Bit. This new tool has a circular cutting edge that lasts 10 to 30 times as

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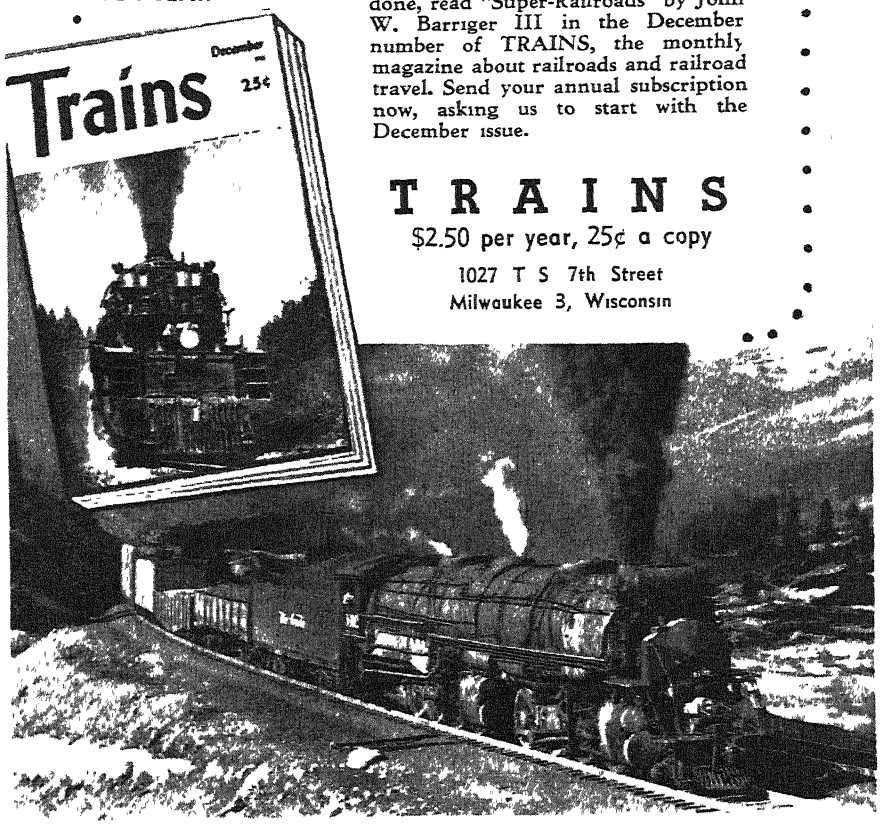

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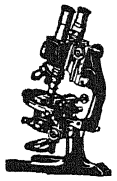

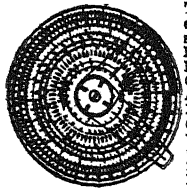

The Binary Slide Rule equals a 20 inch straight slide rule in precision Has C, CI, A, K, Log, LL1, LL2, LL3, LL4, Binary Gives Trig functions to Add and Subtract Scales 1 minute from 0 to 90 degrees. The engine-divided scales are on white enameled metal. Permanently accurate. Dia. 8¼" Large figures and graduations eliminate eyestrain Exceptional value and utility. Price with instructions $5.00, cash or C.O.D. Durable case 80c extra. Circulars free. Your money back if you are not entirely satisfied.
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long as a straight-edge cutting tool before resharpening is necessary. According to the manufacturer, the Shearcut Tool Company, the grinding time saved pays for the cost of the tool before resharpening is necessary.

The shearing (instead of conventional prying) action of the new boring bit leaves a curled chip and allows huge cuts to be taken without chatter. Chips sliding back over the cutting edge have a resharpening action. When an edge

Circular cutting edge is the secret

becomes dull, a new one is provided by simply turning the bit in its holder. No new set-up is required

With cutting speeds up to 1000 feet per minute, the new boring bit requires less power and generates less heat because of the shear cutting action. The mirror finish which this tool produces in one operation meets Navy specifications and usually eliminates any necessity for grinding, filing, reaming, or polishing to remove tool marks. The bit works well with either a positive or negative rake and permits working to closer limits than normally possible.

BAROMETER, ALTIMETER

HIGH SENSITIVITY and precision are combined in two new instruments, suited for use in meteorology and surveying, for airport service, for research work, and as standards for calibrating other instruments.

The instruments have a sensitivity of one part in 8000, and an accuracy of ±0 1 percent. A pointer, moving over a mirrored five-inch dial, makes practically two revolutions in traversing the full scale-range. This is equivalent to a linear scale of approximately 29 inches, and permits scale-readings to one-foot altitude or 0.05 millibars pressure. Inherent temperature compensation of the instruments is extremely high, so that no special compensating elements are necessary.

New altimeter, provided with a pointer that moves over a five-inch dial

Unique simplicity of design, developed by Wallace and Tiernan Products, Inc., helps the instruments to hold their accuracy under severe usage conditions. For portable service, they are available in shock-proof protective cases. They can also be furnished for wall or panel mounting

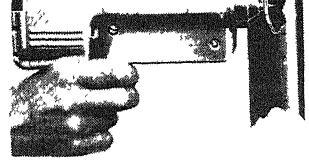
HEIGHT GAGE ADAPTER

RECENTLY announced is a simple height gage adapter which not only enables one machinist's height gage to do the same amount of work formerly done by two units, but also permits a zero reading, a feature which has heretofore been impossible with standard equipment.

The adapter, made by Barentzen Products, consists essentially of a small machined unit which is clamped to the arm of the height gage. The scriber is then placed on the adapter and clamped in place. The result is an adjustable joint which replaces the clamp that formerly held the scriber stationary to the arm of the height gage. With this adjustable joint it is possible to do the things mentioned above, and to get positive dimensions without any pencil-and-paper figuring.

RIVET DRIVER

A NEW device that will drive four "blind" rivets a minute in aircraft production is pneumatically operated and will drive and buck, in one speedy



Blind rivets may be driven rapidly with this light-weight pneumatic tool

operation, the "blind" rivets on finished plane sections to which are connected de-icers, instrument panels, and other light assemblies.

The tool operates in a fast four-step cycle and features a light at the top of the handle which flashes "OK" to indicate to the operator when the rivet has been accurately upset on the "blind" side. The first step in the cycle screws a mandrel into the rivet; the second step pulls back the mandrel, upsetting the rivet and flashing on the "OK" light; the third step unscrews the mandrel; the fourth shuts off the tool, completing the cycle and making the tool ready for the next operation.

Weighing only four and a quarter pounds, the machine measures nine and one half inches in length and has a spindle offset of seven eighths of an inch. Known as the Thor "RIV-Driver" the new instrument makes practical for production use a wider application of "blind" rivets, not only on aircraft but also on scores of other assembly operations.

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(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

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LIFE TESTS OF ELECTRIC DISCHARGE LAMPS, by M. K. Laufer and H. S. Bernstein, is a 19-page mimeographed pamphlet giving the results of a study of cold-cathode electric discharge lamps. Technical development note No. 29. *U. S. Department of Commerce, Civil Aeronautics Administration, Washington, D. C.—Gratis.*

THE ROSAN LOCKING SYSTEM is a four-page bulletin which explains this system for installing threaded inserts and locked-in studs. The system has potential applications in all industries where screw fasteners are used. *Bardwell and McAlister, Incorporated, 7636 Santa Monica Blvd., Hollywood 28, California —Gratis*

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ACME PROCESS NEWS No. 14, a house publication, is devoted to the dissemination of information of value to shippers of war products. The material is particularly concerned with the applications of steel strapping for protecting war shipments. *Acme Steel Company, 103 Park Avenue, New York 17, New York.—Gratis.*

LIGHTING HANDBOOK is a 175-page manual designed as a practical guide and working reference book for lighting engineers, architects, and builders. It will, however, be of interest to anyone concerned with lighting problems. *Westinghouse Lamp Division, Bloomfield, New Jersey.—$1.00.*

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SYNTHETIC DRYING OILS, by A. G. H. Reimold, is a reprint of a four-page article from *American Ink Maker*. It outlines the characteristics and applications of synthetic quick-drying oils which are of such vast importance to American oil and fat chemistry today. *Woburn Degreasing Company, Harrison, New Jersey.—Gratis.*

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Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS
Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

INGENIOUS and controllable way to rig the base of a fairly large telescope which nevertheless must be made portable is shown in Figure 1. Two of the legs have large casters and the third has a loose lift-up lever for towing purposes. This is an 8" telescope and therefore not light. A. J. Walrath, 14024 Archdale Ave., Detroit, Mich., is the maker. It is his first telescope. He writes, "The mirror is larger than recommended for a beginner but no serious difficulty was encountered. With a ½" eyepiece, giving a magnification of 144, the rings of Saturn are clear and beautiful. Jupiter, too, with its moons, can be seen in good detail."

SEVERAL readers have inquired within recent months about a mirror grinding problem. Here is a typical question: "I have passed the roughing-out stage with coarsest abrasive and am now trying to obtain contact with abrasive No. 120 However, the mirror, no matter how much grinding I do, or how short the strokes I use, persists in touching the tool at the edge zone alone."

Remembering a battle with one mirror which persistently acted in the same manner, your scribe dug up a log book for 1930 and from it has worked out the data which follow. It is not, however, claimed that these methods will always work.

Use full-diameter—that is, very long—hogging-out strokes on only the first two sizes of abrasive grains. Thereafter, use regular one third strokes. That is, do not change to short strokes.

Grind with No. 220 abrasive a long time, not alone for pit insurance but also to reduce the gap between mirror and tool to about 1/2000". This can be measured with "feelers."

Let the first feeler be a tiny piece of ordinary paper—say a corner torn from a book page. Lay this on the center of the tool and place the mirror on it. Will the mirror now spin, as on a turntable? Seize the mirror and tool simultaneously between the thumbs and fingers of both hands, on either side, and develop any hidden slight rocking by alternate squeezing. Note an inch of similar book pages, dividing by 2. This gives the feeler's thickness—generally around 1/250" or 1/500". Now you have at least an approximate idea of the space you are dealing with.

To reduce the gap, try painting a ring of wet abrasive in the edge zone.

A method which gave still better results was to invert the tool and mirror and work the tool on the mirror in a series of epicycles limited in width to the center on one side and the intermediate zone on the other (farther might turn the edge).

Another method, which worked up to the hilt on one occasion, was to carry the wet far toward bone dry—10 minutes instead of half that time This requires muscle and there is risk of a sticking mirror, so don't stop or lose full control. This method brought a persistent central gap into central contact very rapidly.

As finer and finer grades are used in grinding, the gap can be narrowed (this probably cannot be done on the coarser sizes) and the space measured with tissue paper feelers, which are generally about 1/800" thick. One can "guesstimate" the rest, up to about 1/2000", by noting the amount of teeter on such a feeler.

Reduce the gap to about 1/2000" on

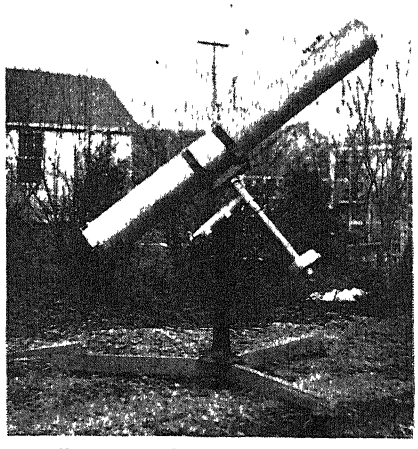

Figure 1: The telewheelbarrow

No. 220 before proceeding to finer sizes of abrasive. The same methods should then further reduce it on the finer sizes.

Since short strokes alone did not solve the problem, while fearless one third strokes with the above methods did, timid fussing with short strokes was thereafter abandoned. (Such timid fussing often leads to other troubles, and grows by what it feeds on. Your scribe recalls futile hours with feeble quarter-inch strokes and no results.)

The carrying-out-to-dryness-and-with-muscle method, described above, was hit on as a result of getting mad at the mirror, one bad day, and not caring what happened to it. On another occasion, this time during polishing, the same method brought about sphericity when short-stroke fussing had failed; vigorous strokes that were longer than orthodox one third strokes (due again to being mad at an evil mirror) brought it to reason in short order. (Or was it the accompanying imprecations?)

The moral seems to be, don't let a mirror bluff you—but at times get tough and give it the works.

Is the gap between mirror and tool, dealt with above, on the mirror or is it on the tool? No answer seems available, nor was one necessary since the empirical method got results. But if any amateur scientist wishes to be a martyr and give such a mirror a polish, just to measure its zones in order to find out, he will be awarded a medal.

The above matter was shown to Cyril G. Wates, Edmonton, Alberta, since it is unsafe to hand out advice on a basis of a single experience, because too often some hidden personal factor is involved. Wates commented: "My experience has been that a one third stroke applied with vim, vigor, and vitality is a cure for many mirror evils—almost a panacea I have had mirrors with zones that looked like the Rocky Mountains clear up perfectly after a 15-minute session of 'the works.' I use a machine.

"Yes," he continues, "it is hardly possible to obtain contact with coarse abrasive—I too find it a matter of approach only as finer and finer sizes are used. For, even if you got perfect contact with No. 80 or 120, you couldn't keep it."

One reader to whom the above methods were explained in a letter reported, "I tried the 'spit-on-your-mitts-and-punish-it' method but it wasn't very effective. I then tried inverting the tool and mirror, with elliptical strokes, as suggested, and one wet took the mirror down to almost perfect contact. It solved my problem."

TREES make a wonderful support for a mid-summer hammock but often they have virtually prohibited amateur telescope makers from having an observatory dome. Your scribe, for example, lives in a deep "hole" between 90' oaks on neighbors' lands and cannot even mount a telescope. How, then, about a dome atop a tower?

Figure 2 shows how Earl Manbeck, Jr., 3920 Cottage Grove Avenue, Des Moines, Iowa, got above the trees; he built a 23' tower, 10' square, and put the observatory on it.

"The tower," he writes, "is made of wood bolted together, and my neighbor, E. H. Ruby, helped me a great deal. The deck is made of 2" lumber. A 12" reflector, which I purchased second hand, is mounted on it. The dome is 14'6" in diameter and made of iron ribs and sheet metal."

Asked whether this arrangement was steady, Manbeck at first replied that it was, but after 12 days of observing with the telescope he reported that "I have found that when other persons are present it is necessary for everyone to stand still, otherwise the telescope picks up a lot of vibration. So we are going to put in the suggested central pier, separate from and at no place touching the tower."

This note is published to forewarn readers against towers in which the telescope is an integral part of the tower. Possibly such a tower could be

made steady enough, at great expense, but the separate pier is probably cheaper.

When your visitor prances around or even scratches his ear, your physical senses will hardly detect the vibrations in the tall tower structure—direct. But your eye, at the eyepiece where the vibrations are many times magnified, probably will and all too well—for a telescope is a magnifying seismoscope. An amateur in Washington, D. C., once related how his telescope on the roof of an old, lightly built, wooden-framed four-story apartment house always told him when the ladies were beating eggs far below in the kitchen. Not, however, that a telescope atop a whole house will necessarily be unsteady—it has been done and has proved good. Much, however, depends on the house. But a tall tower usually lacks the mass of a whole house.

FIVE YEARS is a long time to hide one's light under a modest bushel. Frank A. Jasset, Newton, Mass., assisted by Frederick Richards, Newton, Mass., and Guy E. Gordon, Natick, Mass., five years ago finished a Cassegrainian reflector (Figure 3) of 20″ aperture and then failed to write it up for publication.

Learning recently about this telescope we invited Jasset to give us the pertinent data, and these now are published —perhaps more briefly than would otherwise have been the case. We wonder how many other larger-than-average telescopes lurk elsewhere, similarly unheralded and unsung.

The observatory is wooden and is 10′ x 10′, with a square pyramidal roof revolving on a "round-square" track.

Concrete pier separate from floor.
Springfield-type mounting.
Electric drive.
Tube, 21″ x 61″.
Primary, 1½″ x 20″, 47″ f l.
Secondary, 4″ diameter.

There is a 2″ right-angle prism at the elbow near the eyepiece.

At first the primary was silvered and coated with amyl acetate, which worked very well, but when no amyl acetate was applied to a later coating the silver soon tarnished rather badly

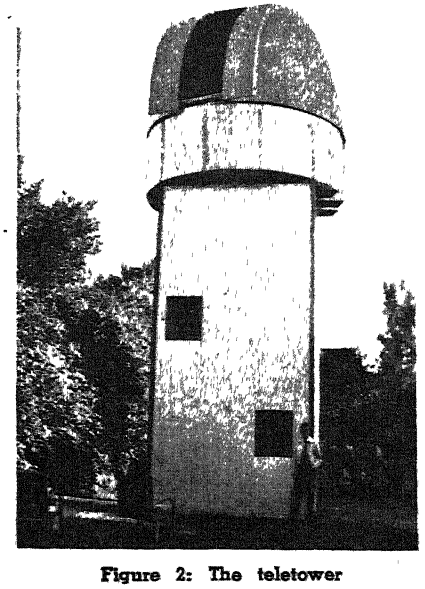

Figure 2: The teletower

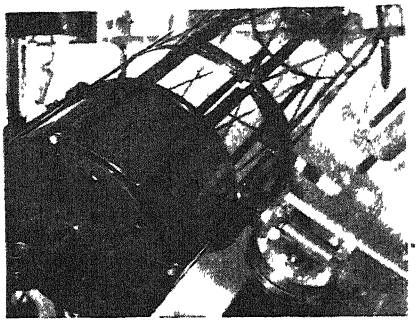

Figure 3: The bashful 20″

Asked about the unconventional thinness of the mirror, about 1:13, Jasset replied: "Definition very good, no distortion. The mirror rests on a flotation system resting in turn on felt blocks on a disk of 1½″ laminated wood sealed with wax and painted. This has proved very satisfactory.

Jasset and Richards, also Gordon, were members of the recent "Roof Prism Gang." Because working only in spare time, of which there was not enough, they were unable to go into actual production but together produced 36 acceptable roof prisms and thus demonstrated that in more favorable circumstances they could have produced many. The initial belief on the part of your scribe, that the amateurs could make these prisms in spare hours, was mainly erroneous. The work proved to be too exacting for tired men who already had done one day's work. With one exception those who produced large numbers—thousands—were those who could arrange to quit their regular vocations and go into prism production whole time (actually, in fact, for most, about double time, with sleep taken mainly after the emergency). The exception was the team of Ralph Franklin of Patchogue, N. Y. and Frank Cameron, Inwood, N. Y., who, together, produced 1700 roof prisms in spare hours—and felt about 100 years old during the long period of the doing. Today, all the roof prism work is completed.

LAST MONTH's Telescoptics department dealt with the effects of temperature in different types of telescope tubes. In addition to the effects described there and previously in astronomical literature, a reader contributes a new one so far as this department knows—the huddle, or "crowd poison" effect. Too many people crowding around a telescope together give off about as big a volume of heat as a small bonfire; one human being alone sheds heat at a rate of about 400 B.t.u., about enough to light a lamp bulb. That's why the poor telescope aches to yell "Spread out—crowd poison. And quit breathing on my eyepiece or I'll get hot and put on some temperamental aberrations or go into a coma if you persist in ganging up on me this way." A crowd indoors will warm a room; even outdoors it will suffocate a telescope.

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COVER: Dramatic is the scene in a foundry when slag remaining in the bottom of the "bull" ladle is dumped into the cinder bucket after the steel has been poured. Equally dramatic, and far more important to our industrial world, is the story of technological progress that is being made in all branches of the foundry industry. For details see the article starting on page 115 of this issue.

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Previews of the Industrial Horizon

By A. P. Peck

WOOD IN THE FUTURE

EVIDENCE that the wood industry—mildly castigated in the item on paper published on this page in our January issue—is doing something about the problems of perpetuating their raw material source, is to be found in information which has just come to hand.

For years Scientific American has advocated forest conservation. Trees are living, growing things which constitute our only regenerating natural heritage. Once coal or oil are removed from the ground, they cannot be replaced. But if forests are scientifically managed—intelligently harvested and replenished by adequate replanting programs—they can continue indefinitely to serve the needs of mankind.

What is needed, then, is continuing active work on the part of the wood industry as a whole to provide the means whereby new growth of wood will annually equal or exceed the amount harvested. An estimate made in 1920 placed wood growth at six billion cubic feet a year; an equally reliable estimate made in 1936 (the last year for which figures are available) indicated an increase to over 11 billion cubic feet of growth, or only 20 percent less than the total amount of wood harvested that year plus the losses due to fire, insects, and disease.

Here is definite encouragement that the gap between wood use and wood growth is closing. Reserves still dwindle, but the rate of dwindling is slackening. For the long pull this is significant, since industry is constantly finding new uses for wood. As the chemical industry calls for more and more wood to use as a basic raw material, as paper products increase in applications, as construction work puts into active use the recent developments in wood fabrication, the demand for wood will increase beyond anything ever dreamed of in the past.

Thus, when scientific management of forests hits its full stride, and there is every indication that it will do so in the not too far distant future, industrial America will be assured of a continuing supply of this needed material.

FAIR AND COOLER

NOT all the technological advances now held in abeyance, so far as the ultimate consumer is concerned, are traceable directly to the war effort. A case in point is the unit room cooler and air conditioner, for summer comfort and for treatment of some respiratory ailments, which was just beginning to come into its own in 1941. Estimates for post-war production of these units range from 100,000 to 200,000 per year, but The Crosley Corporation, always optimistic about the right product at the right price, foresees sales of such units soaring to the mark of a million annually.

Certain it is that room coolers offer decided advantages of comfort and better working conditions; equally certain is the fact that recent improvements in materials and know-how can be applied to production of units superior to those made in 1941. Post-war potential market for such coolers will undoubtedly be large. Whether the million a year mark will be reached depends upon the ingenuity of industry

RADIO ON THE RAILROAD

FOR many years sporadic experiments have been conducted with radio communication between fixed stations and moving trains. Radio receivers have become standard equipment, for entertainment purposes, on many trains. Other applications of this form of communication to railroad work have been toyed with and then dropped.

Now, however, there is a spot on the horizon that, from this distance, appears to presage the use of standardized radio equipment on railroads for routine dispatching purposes. Undoubtedly such usage would supplement wire dispatching, the block system, and other railroad safety installations. But radio would go farther than anything now used. It would tend, by providing a continuously operating means of communication with train crews, to reduce greatly the possibility of disasters of the type that have been occurring all too frequently on American railroads in the past few months.

CHEMICALS FROM GAS

LOOK upon natural gas as a raw material source for the chemical industry in the near future. Virtually a chemical twin to petroleum, natural gas is currently being used to the extent of over 95 percent of production for industrial and household fuel. It is entirely probable, however, that more and more of this gas will be diverted to other purposes.

Butadiene, glycerine, carbon tetrachloride, gasoline, sulfa drugs, and fertilizers are some of the products available directly or indirectly from natural gas. Upon such possibilities can technology build an important chemical future for this product of nature.

PNEUMATIC DISPOSAL OF REFUSE

SEEMINGLY fantastic propositions, when backed by the solid judgement of qualified technicians, deserve studied thought before dismissal. Thus when sanitary engineer Morris M. Cohn, of Schenectady, New York, proposes that the refuse of cities of the future be disposed of through intricate systems of pneumatic tubes, the idea should not be dismissed too abruptly as impractical.

Garbage, ashes, and household refuse of all kinds would be handled by the tube systems, equipped with air-lock chambers at each point of entry and powered by strategically located booster stations to maintain adequate suction.

Such a system, as Mr. Cohn says, would require a "complete re-orientation of engineering ideas." It would also provide a huge market for construction materials and labor

UNIT HEATERS

RELIABLE report has it that there has been developed for the United States Army a portable, self-contained and self-powered forced warm-air furnace that weighs only 45 pounds and is about the size of an average suitcase. Although details are still under the well-known cloak of military secrecy, it is apparent that this furnace will circulate enough warmed air to meet the needs of the average family home during even very cold weather.

Here, it appears, is a possible logical answer to many home-heating problems, from the complexity of the conventional heating system to the high cost of fuel.

TIN TOMORROW

PROBABLY the worst-squeezed of all the metals during the war emergency has been tin. As a result of substitution necessities, many other products have been developed to replace tin in various uses, often with advantages not offered by the shiny metal. Here is something that tin is going to have to overcome in the post-war world and to this end the tin industry is already planning a campaign of research and information dissemination. This is going to be an interesting development to watch and one which promises results.

50 Years Ago in . . .

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ELECTRIFICATION — "Work has been begun on the Baltimore and Washington Electric Railway. The electric line will be only 32 miles long, while the Baltimore and Ohio's steam road is 40 and that of the Pennsylvania 42 miles in length between the two cities."

CONDUCTIVITY — "At ordinary temperatures copper is six times better a conductor of electricity than iron, but the conductivity of each is increased by cold. Copper is ten times better as a conductor of electricity at —100 degrees than it is at the freezing point of water, and the conductivity of iron increases at a still greater rate until iron becomes as good as copper.

ENERGY — "Prof. Langley demonstrates that if a body of coal sufficiently large to last the United States a thousand years should be set on fire, the heat given forth from it would not equal that which the sun gives out in the thousandth part of a second."

HAITI — "Mining interests have hitherto been wholly neglected in Haiti, and her resources in this respect are kept in the background and seldom referred to. Nevertheless, it is well established that gold, platinum, silver, copper, iron, tin, manganese, antimony, sulphur, rock salt, bitumen, etc., exist."

VEGETABLE SILK — "Kapok may be employed in lieu of cotton for preparing a detonating powder by treating it with nitric acid. This nitrated kapok, mixed with pyroligneous ether, and with protochloride of iron having an organic base, yields a reduced fiber, which, differently colored, furnishes a solution of vegetable silk which solidifies in water and may be spun and afterward mixed with animal silk."

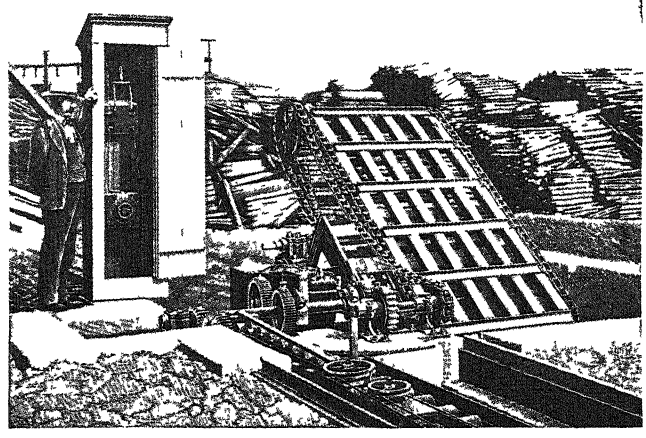
FURNACE LINING — "Magnesia is claimed to be capable of standing far higher temperatures than other kinds of brick, the principal difficulty in using it being the excessive shrinkage to which it is liable when heated. . . . M. Lencauchez claims to have overcome these difficulties, and has exhibited a number of perfectly solid bricks of magnesia, which were as dense as granite, and had been thoroughly shrunk."

CONSERVATION — "Inventive genius has done much for the human race. It has taught mankind to utilize most of the products of nature. Hereafter it must lead to the conservation of natural resources and to the hoarding of natural capabilities. . . . Within a few generations such economies will not be expedients; they will be necessities."

TUBE SERVICE — "A pneumatic tube service between the offices of the various newspapers and news associations of Chicago has just been put in operation. . . . About one minute is required for a carrier to traverse the longest line."

ELECTRICAL DIFFICULTIES — "The want of suitable refractory material for the incandescent lamp filament, the high capitalization required for electric generating plants, the poor economy of the steam engine as a prime motor for driving dynamos, are samples of the difficulties which the electric engineer has to contend with. It is to be hoped that the inventor will dispose of enough of them to make electricity take the place it is fairly entitled to."

POWER LOADING — "At the works of the Illinois Steel Company, at Joliet, Ill., electrically transmitted power is now used in many operations with great economy and convenience. Our illustration represents an electrical apparatus



employed to load steel billets on flat cars. . . . The billets to be shipped are delivered to a long line of rollers, partly shown at the left in the illustration, and are thus carried along until they strike a deflecting plate by which they are conveyed to an endless moving apron, set at an incline, as prominently shown in the picture. This apron first elevates and then drops the billets on the car to be loaded, which is on a depressed railroad track on the farther side. This loading machine is driven by a twenty-five horse power 500 volt motor, the controlling switch and rheostat being conveniently placed in a small switch house"

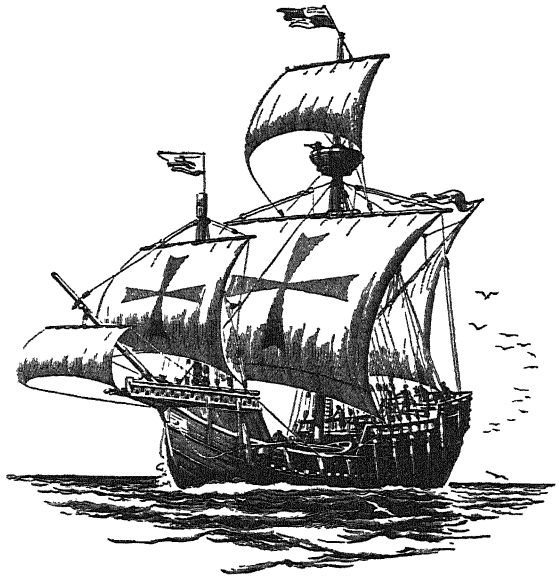
HORSEPOWER — "It has been estimated that 25,000 horses are employed in the London carrying trade, that their value is a million and a quarter, and that the cost is for food alone £800,000 a year."

ALMOST GONE — "The elevated railroads of New York City carried 221,000,000 passengers during 1893. . . . The number of passenger coaches employed in the service is 1,116, and 75 new ones were added during the last four months."

STEEL SHIP — "At the yard of Arthur Sewell & Co., Bath, Maine, the first steel sailing ship built in America was launched on Feb. 17, 1894. . . . The vessel is rigged as a four-masted ship, being square rigged on three masts, the lower masts and top masts all being in one length."

PLASTIC FLOW — "In the view and understanding of the tendency to molecular flow in all structural material toward a weaker form or condition, especially in tensional members, it is a most important consideration that the factor of safety should be largely increased in every structure in which life and property may be jeopardized, whether it be a machine, a boiler, a vehicle, a building, or a bridge. Absolute safety should be the prime axiom of construction. . . . The measure of the force necessary for the flow of solids varies greatly in different materials, due to varying molecular adhesion. The hardest materials known are no doubt subject to molecular change of form under pressure, but as we can only use the hardest and most resisting material for producing pressure, there is an apparent limit at which we can prove the flow of solids."

AUTOMOBILES — "While waiting until electricity shall have put in its last word concerning the propulsion of vehicles, a warm contest is continuing between steam and petroleum carriages, without counting those actuated by a compressed air motor and that are coming in their turn to take part in this pacific tournament."



THERE ARE STILL

UNDISCOVERED CONTINENTS

COLUMBUS had a definite goal—a westbound sea route to Asia. But what he found was a new continent—a new source of Nature's wealth.

Modern research also has its goals: it, too, is discovering new resources. Starting from the knowns of science, it charts its voyages into the unknown. Behind each voyage is a theory that there is a passageway.

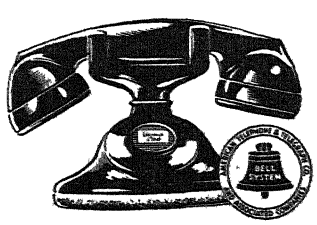
But research doesn't hold stubbornly to its theories. If it finds islands instead of a continent, it accepts them, for it expects the unexpected. It studies their relation to the known lands of science. And on the basis of its increased knowledge, it makes revised plans for progress. In science there is always a continent ahead.

Just what research will disclose can never be forecast. But history has proved that from research flow discoveries of value to mankind. From Bell Telephone Laboratories there has poured a full stream of improvements in the telephone art.

Bell Telephone Laboratories has kept America leading the world in telephony. And its researches have contributed importantly to other arts of communication—to the phonograph and sound-motion pictures, to radio broadcasting and television.

Today, as ever since Pearl Harbor, its efforts in research and design are devoted to the war needs of the nation.

When peace comes, its organized teams of research scientists and engineers will continue to explore and invent and perfect for the improvement of telephony.



BELL TELEPHONE SYSTEM

An Important Message to

Technical Men

The war has carried the manufacturing age to a new peak! Production demands have created technical problems the like of which the world has never seen before! The services of engineers are at a premium. Especially the services of one particular class—executive engineers—*engineers with business training;* engineers who can "run the show."

In these critical times, the nation needs engineers of executive ability *now, today* —not five, or ten years from now! The shortage of such men is acute—even more acute than that of skilled production workers. And company heads, aware of this situation, are offering high rewards to engineers who have the necessary training in industrial management.

Golden Opportunity for Engineers

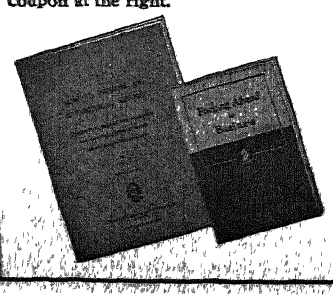
In this new era, the engineer with vision and foresight has a golden opportunity. He will realize that out of today's tremendous production battles will emerge technical men who not only will play a major role in winning the war, but who also will be firmly entrenched in key executive positions when peace comes.

However, before the engineer can take over executive responsibilities, he must acquire knowledge of the other divisions of business—of marketing, accounting and finance. He has of necessity a vast amount of technical training and experience. But in order to grasp the opportunities that present themselves today—to assume leadership on the production front—he must *also* have an understanding of practical business principles and methods.

The Alexander Hamilton Institute's intensive executive training can give you this essential business training to supplement your technical skill.

FREE help for engineers

Ever since the war began, there has been an unusually heavy demand on the part of our technically-trained subscribers for the Institute's special guide on "How to Prepare an Engineering Report". Extra copies of this practical, helpful 72-page Guide are now available and, for a limited time only, will be sent free to all technical men who use the coupon at the right.



134,000 men on the operating side of business have enrolled for this training. More than 37,500 are technical men—engineers, chemists, metallurgists—many of whom are today heads of our huge war industries.

This training appeals to engineers because it gives them access to the thinking and experience of the country's great business minds. It is especially valuable to such men because it is basic, not specialized—broad in scope, providing a thorough groundwork in the fundamentals underlying *all* business. It covers the principles that every top executive must understand. It applies to all types of industrial organizations, because all types of organizations are based on these same fundamentals.

Business and Industrial Leaders Contribute

The Institute's training plan has the endorsement of leading industrialists and business men. And it is only because these high-ranking executives recognize its value and give their cooperation that such a plan is possible. Among those who contribute to the Course are such men as Frederick W. Pickard, Vice President and Director, E. I. DuPont de Nemours & Co.; Thomas J. Watson, President, International Business Machines Corp.; James D. Mooney, President, General Motors Overseas Corp.; Clifton Slusser, Vice President, Goodyear Tire and Rubber Co. and Colby M. Chester, Chairman of the Board, General Foods Corp.

Send for "FORGING AHEAD IN BUSINESS"

The facts about the Institute's plan and what it can do for you are printed in the 64-page book, "Forging Ahead in Business". This book in its own right is well worth your reading. It might almost be called a handbook of business training. It is a book you will be glad to have in your library, and it will be sent to you without cost. Simply fill in and mail the attached coupon *today.*

Alexander Hamilton Institute,
Dept. 35, 73 West 23rd Street, New York, N. Y.
In Canada, 54 Wellington St., West, Toronto Ont.
Please mail me a copy of the 64-page book—"FORGING AHEAD IN BUSINESS" and also a copy of "HOW TO PREPARE AN ENGINEERING REPORT," both without cost.

Name.....

Business Address.....

.....

Position.....

Home Address.....

"Quotes . . ."

"WHEN VICTORY comes, the measure of America's greatness and worthiness will be her ability to turn the war production machinery which has been designed primarily for destruction, into effective peaceful purposes" *Arthur W Herrington, Board Chairman, Marmon-Herrington Company, Inc.*

" " "

"*FREQUENTLY THE lack of a single ingredient of technical information in a plant has resulted in a lost contract, and one of the basic difficulties of small manufacturers has been a lack of adequate research facilities to meet present-day production problems.*" Brigadier General Robert W. Johnson, Chairman, Smaller War Plants Corporation.

" " "

"GREATER STABILITY in production will pay high dividends in the form of lower unit costs, lower taxes, and lower relief costs, as well as less social and political unrest and better industrial relations within the plant" *Eric A. Johnston, President, Chamber of Commerce of the United States.*

" " "

"*IF INGENUITY is the ability to solve problems, this implies the ability to do creative, original work. Unfortunately, the successful completion of an engineering curriculum does not necessarily imply a high degree of ingenuity If educational institutions have any value in the development of ingenuity, they must stimulate rather than kill intellectual curiosity.*" Henry T. Heald, President of the Illinois Institute of Technology

" " "

"WHEN THE HISTORY of this war is written, tribute must be paid to American teachers who, grasping the vital importance of aviation in our national defense, converted classrooms into veritable airports, shops into model aircraft assembly plants, and laboratories into preflight training centers." *Advisory Board, Air-Age Education Research.*

" " "

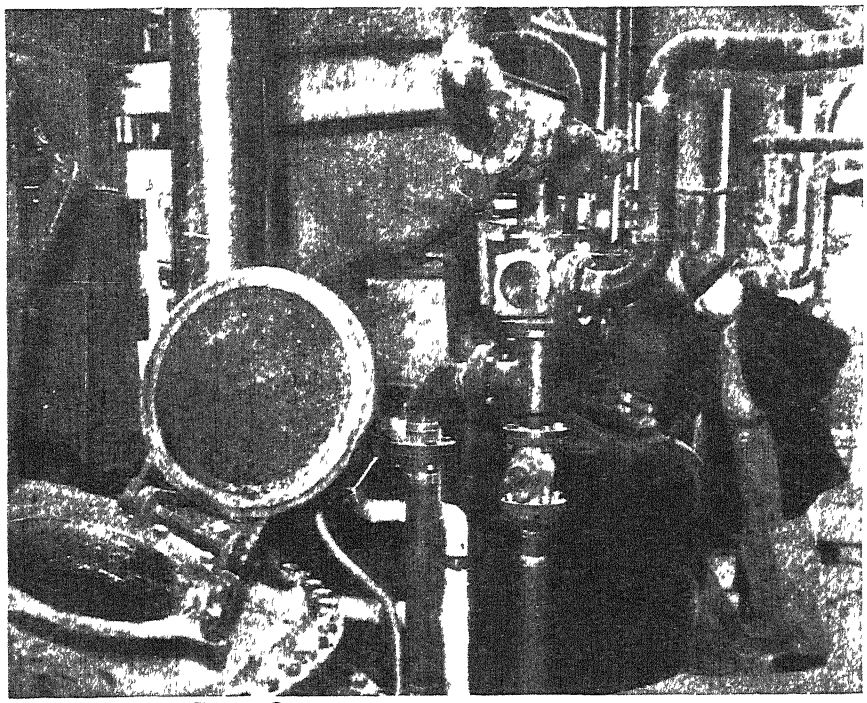
"*IF FARMERS would only consider farm woodlands and farm forests as cropland, and carefully cut selected trees every year—the ones that are ripe for harvest—they would be surprised by the amount of their returns and they would certainly aid the war effort.*" H H. Bennett, Chief of the Soil Conservation Service.

" " "

"RECONSTRUCTION AFTER this war means the rebuilding and restoration over vast areas of the world of all the facilities and essentials of modern civilization, laid waste by the flames of an incendiary war, the most destructive in human history." *Eugene P. Thomas, Chairman, National Foreign Trade Council.*

CHEMISTRY IN INDUSTRY

Conducted by D. H. KILLEFFER



Courtesy Monsanto Chemical Company

Reaction kettles in which synthetic resins are produced

Plastics Tomorrow

Will Plastics Become the Miracle Workers Predicted by Some Enthusiasts? Practical Experience, Gained by the Industry, Shows What They Can and Cannot be Expected to Do. Plastic Ships, Automobiles, Houses? Economic Limitations Give the Answer

PLASTICS are prominent in plans for the post-war world. They should be. Nothing else equals the versatility of these synthetic products of chemistry's pots and kettles, and nothing else possesses such promise for rebuilding our war-torn industrial economy. Yet plastics are less novel and strange than one might be led to believe by enthusiasts who have only lately discovered their amazing variety and usefulness. Actually, an important body of experience in the fabrication and application of plastics has been accumulating over several decades, and this is now being put to widening use with an effect almost of the miraculous. Insoluble problems of production in other materials seem to vanish when plastics enter the plant. That heightens the miracle. Serious suggestions are being advanced that even our houses, our automobiles, our ships, may soon be drawn cheap, complete, and finished from the wonderful grab bag of plastics.

Now, one would be rash indeed in this swiftly moving age to risk stating that anything is impossible, particularly in plastics. But enthusiasts often mislead themselves. That is what seems probable in this instance. Many essential limitations of the plastic art, well known to experts, are being overlooked. Even when these limitations are considered, however, the future of plastics is still immensely attractive. Just now, plastics achieve special prominence by taking the places of scarce and restricted materials that have gone to war. Tomorrow, their value and versatility will secure for them important places of their own in our industrial world.

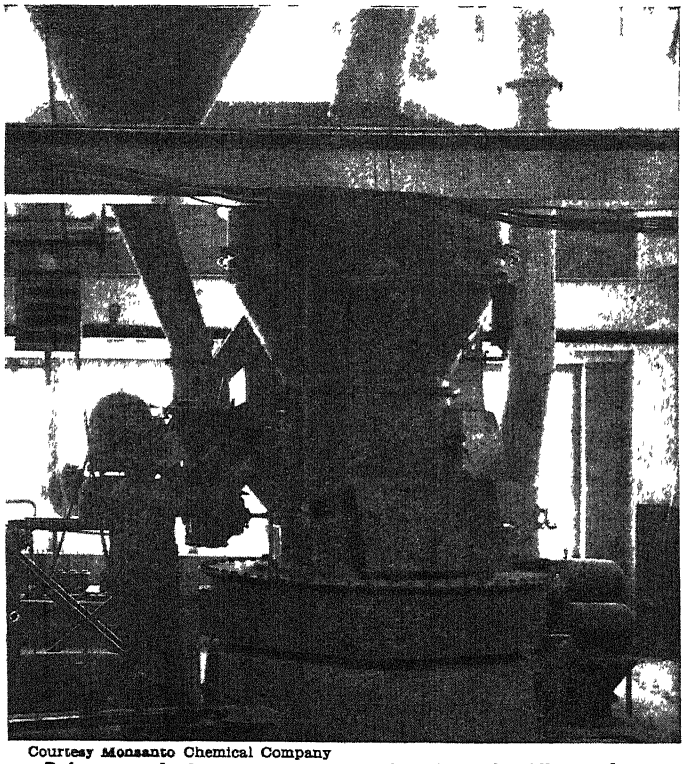
Just to be sure of what we are talking about, it would be well here to define plastics. Actually the term includes all materials capable of being molded by pressure. In the currently accepted sense of the term, however, glass, ceramics, metals, and a number of natural gums and resins are ruled out and the field of plastics embraces primarily the synthetic resins, and compositions made from them, which are capable of being formed by heat and pressure. To these must be added a number of semi-synthetic products, particularly those derived from cellulose by chemical treatment (cellulose nitrate, acetate, butyrate, and its ethers, particularly methyl and ethyl cellulose), and moldable products made from the lignin of wood.

The plastic as molded commonly consists of a mixture of a synthetic resin with a filler of fibrous material added to give the desired characteristics to the final product. For example, a mixture of phenol and formaldehyde may be carried partly through the chemical reaction converting it to resin and then mixed with wood flour or glass or asbestos fibers to form the plastic mass to be shaped in a hot mold under pressure into a distributor cap for an automobile engine. Or a similar, partly formed resin may be spread upon layers of paper, canvas, or wood veneer and the whole pressed hot into slabs or sheets.

The function of the filler in a plastic usually is to offset some shortcoming of the resin alone (brittleness, for ex-

simple) and to impart some particular property to the finished article. Other articles—pipe bits, beads, and the like—may consist of practically pure synthetic resin with only coloring added.

Even when so defined and limited, the term plastics covers a vast number of different materials having properties of the utmost diversity.* Some resins are as tough and elastic as rubber, others are as soft as chewing gum; still others are semi-liquid, resembling thickened fatty oils; and some are hard, brittle, and almost glassy. Indeed, the hundreds of different industrial plastic materials suggest that the principal similarity between them lies in their common synthetic origin. Upon that great diversity of properties depends the extraordinary breadth of usefulness of these synthetics. It also prevents generalizing about them, since a statement true of one is quite sure to be entirely false if applied to some other. On the one hand certain phenol aldehyde resins possess extreme resistance to solvents of all kinds; but others of even the same family are useful because they can be dissolved with relative ease in linseed or tung oil. Certain transparent resins permit the free passage of ultraviolet light, a valuable property in some applications; but this property must be nullified if these plastics are to be used in the windows of high-flying airplanes where ultraviolet can quickly cause serious sunburn.



Courtesy Monsanto Chemical Company

Before synthetic resins are combined with fillers, they must be powdered in a roller mill such as the one shown

COMPETITION OF MATERIALS—To class such a variety of materials together is quite impossible from the layman's point of view. Indeed, they possess little beyond their origin in the pots and kettles of the chemical industry to fit them into a single class. Their competition with other products comes from every direction; metals on the one side and wood and drying oils on the other serve some of the same purposes as are served by synthetic resins and their plastics. It has even been seriously suggested that houses of wood and stone will give way to plastic residences; that steel and the light metals, aluminum and magnesium, will feel sharp competition from plastics; that vegetable oils now long used in paints and varnishes will give way before synthetic resins.

The great value and diversity of these synthetics recently led Robert J. Moore to suggest a fourth kingdom, the synthetic, be added to the traditional three—animal, vegetable, and mineral—kingdoms of our childhoods. While the intention was to include in this new realm all the vast range of products of chemical synthesis, Dr. Moore's suggestion applies with special force and aptness to plastics. To proclaim that plastics provide the key to post-war prosperity is almost in the same vein as would be crediting that significant role to the animal kingdom. The important difference lies in the fact that plastics must be manufactured and thus will provide opportunities for the exercise of ingenuity, jobs for many people, and useful employment of capital.

In the swift recent rise of the plastics industry to outstanding prominence, the actual volume of its output has been overlooked. That is not strange since the figure increased by more than 50 percent in the two years between 1940 and 1942 (the latest year for which reliable statistics are available). The United States Tariff Commission notes that production of synthetic resins in 1942 reached a total of nearly 427 million pounds, including all types whether used for plastic molding or not, but without the large and important class of plastic cellulose derivatives. Furthermore, their average value was nearly 40 cents a pound. It is, of course, true that plastics are generally somewhat cheaper than the pure resins from which they are made, but even at that they are obviously not cheap enough to compete successfully with many natural substances—wood, for example—except where some special advantage is gained through the special properties of the plastic.

Because plastics are readily and cheaply molded into intricate shapes, their field of usefulness is immense, but not limitless in a practical sense. The fact of molding itself immediately establishes certain economic limits. It naturally presupposes a mold and that entails a serious problem of constructing one to serve. Obviously the construction of a mold large enough to mold a ship or a house would present engineering difficulties of the first magnitude. To justify the labor and expense involved in such an undertaking, many thousand identical units would have to be produced from each mold, in order that no one of them would be unduly burdened with the immense first cost. The same reasoning holds for the manufacture of even small items. Buttons, for example, can readily be molded of plastics of several kinds, but the operation requires the construction of a hardened steel mold for each type and size of button to be produced. If millions of buttons are needed, then the cost of the labor involved in cutting the initial mold can be readily absorbed, but the production of a few dozens or even hundreds of identical buttons would be prohibitively expensive.

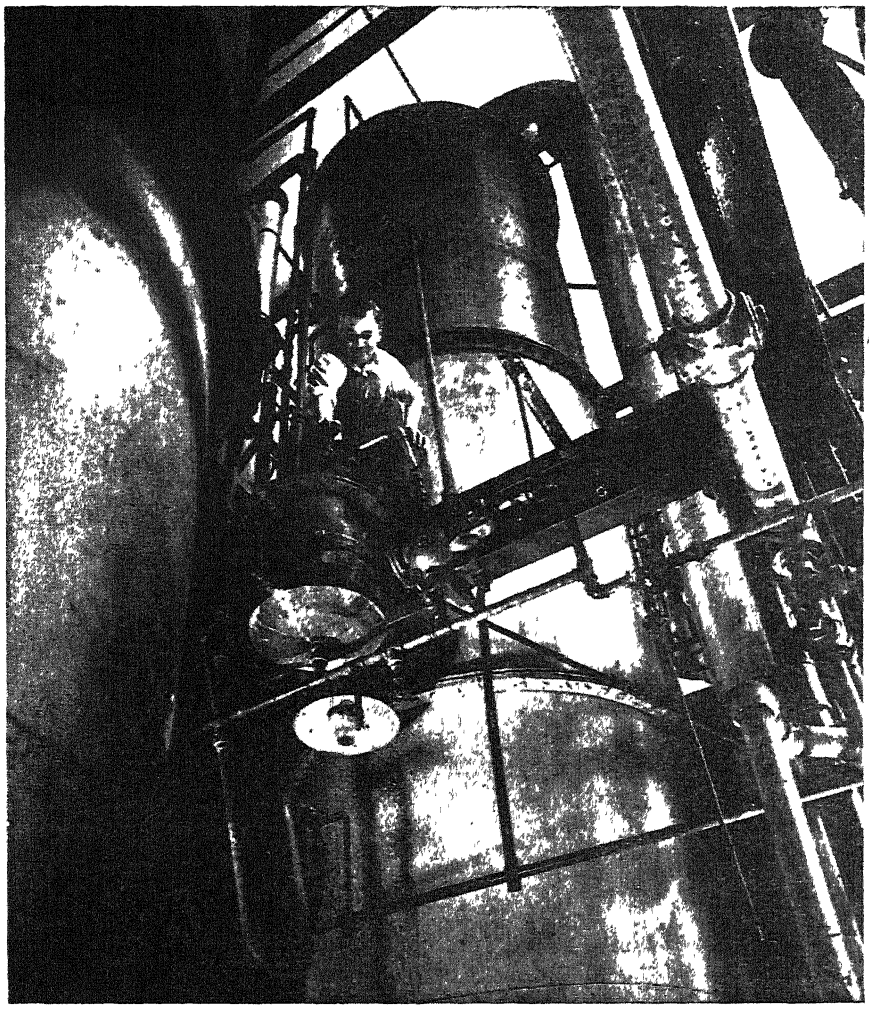
Obviously, then, the plastics industry must depend for success upon quantity production of vast numbers of identical items. There are exceptions to this as to all rules, but, generally, competition with other methods of attaining a like result definitely limits plastic technique to the production of vast numbers of exact duplicates of the original.

For the benefit of those who see in plastics a threat to other industries, it will be well to compare current output of synthetic resins (decidedly the highest yet recorded in the industry's history and still growing) with that of other materials. The present threat to wood and steel is insignificant since the ratio of outputs is of the order of 500 to 1. Set alongside aluminum and magnesium, plastics show up better, with ratios of production 7.5 and 1.5 pounds of the metals respectively to one of plastics.

NOT REPLACEMENTS—Clearly, the future of plastics does not depend on their ability to replace completely any of these important major materials. Rather, they will find useful niches for themselves where their peculiar values will supplement those of the commoner materials. It is foolish to imagine entire houses molded from plastic. As has been noted, the extraordinary engineering problems of constructing a mold large enough to form even a single room quickly throw out such ideas even if the cost of material required were not too high to think about. On the other hand, the valuable properties imparted to wood veneers by modern techniques of laminating several layers with weatherproof synthetic resins as binders have given the architect and builder the equivalent of a new material of construction.

Instead of confining their plans to wood planks of the sizes ordinarily

*For a comprehensive survey of specific plastics [illegible] see page 183, October 1943 issue of Scientific American.—The Editor.



Courtesy E. I du Pont de Nemours and Company
Formaldehyde, made here, is essential in two important families of plastics

available, architects can now utilize a few relatively thin sheets of plywood of large area to form either exterior or interior walls. Building costs can thus be reduced by replacing man hours of labor needed on the site with machine hours in a plant forming the units of the building. Advantage can be taken in this way of the cheapness of wood as the base material, with synthetic resins employed to overcome its deficiencies.

A similar technique has been outstandingly successful in the construction of swift PT boats and Mosquito bombers. Since these units are decidedly too large to be economically molded as single pieces, they are produced by the assembly of units than can be molded to the best advantage when all factors are considered. These methods have been developed to a point of general practicability in the rush of production for war; plants for applying them are already built and can be converted with little difficulty to peace-time production.

A HUNDREDWEIGHT OF PLASTICS—The construction of automobiles from both light metals and plastics has been seriously proposed. Both will undoubtedly be widely used but neither can be expected to exclude the other; certain parts of the car will of necessity still be made of steel. The quantities of plastics required by the automotive industry even as supplements to other materials becomes staggering. A recent estimate suggests that 100 pounds of plastics might readily be used in each vehicle. Even that amount would consume the entire present-day production of the plastics industry if the output of cars should even approach present estimates.

Obviously, then, the plastics industry must grow tremendously if it is to fulfill its post-war promise. This fulfillment need not involve any techniques not already reasonably well tried and immediately available for use. The industry is yet small as industries go, but it contains the germs of substantial growth. It will bear close watching, but it is not a miraculous answer to universal needs. The sooner that general thinking is based on this fact, the sooner will the practical possibilities of the future of plastics be realized.

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PHOSPHATE FEEDS

Supplied from Rock For Animal Use

ANIMAL diets normally have included relatively large quantities of skim milk, supplying both protein and phosphorus, but the demand for milk to be powdered for overseas shipment to our armies and our allies leaves little over for farm animals. Meat scraps, too, have become scarce in feeds. Protein is readily supplied in the form of various seed meals, particularly soybean meal, but these do not supply the phosphorus also required

The best source of phosphorus is bone meal; failing that, phosphate rock is being processed to make available the required element. Natural rock phosphate contains fluorine and this must be removed to make it suitable as a feed Fusion of the rock by heat and conversion to metaphosphate by treatment at high temperature with phosphorus pentoxide are two of the several methods being investigated to produce a feeding grade of phosphate from the rock The Tennessee Valley Authority is studying the problem and fused phosphate rock is already being supplied to stock raisers by veterinary firms.

ALCOHOL SOLUBLE

Lacquer Component for Many Purposes

A NEW grade of nitrocellulose for use in lacquers and possessing improved solubility in alcohol has recently been developed by the Hercules Powder Company. The usual grades require mixed solvents (alcohol and ether) or esters (butyl acetate, for example) to dissolve them for use in lacquers. The new product dissolves in alcohol containing minimum amounts of other solvents and the solutions can be employed for many special lacquer purposes. The saving of scarce and more expensive solvents is important in the present emergency.

LOW-LOSS INSULATION

Provided by Chemistry for the Electrical Industry

PROBLEMS of insulation for the swiftly expanding range of high frequencies employed in modern electrical applications are being solved by polystyrene plastics of specially high purity, according to John J. Grebe, Director of Physical Research, Dow Chemical Company, in accepting the 1943 Chemical Industry Medal.

An extremely low dielectric constant can be obtained with polystyrene and other hydrocarbon resins by elimination of impurities and of additive agents that might have molecular or atomic resonances at the electrical frequencies encountered, Dr. Grebe explained. In this way, polystyrene, which the speaker called the "pig iron" of the plastics industry, attains properties essential to the insulation of conductors carrying currents of ultra high frequency at minimum power loss.

Recent developments employing ultra high frequencies that will be benefited by low-loss insulation include radio locators vital in the present war and high-frequency heating that may become the cooking method of the future. These are in addition to radio and television applications.

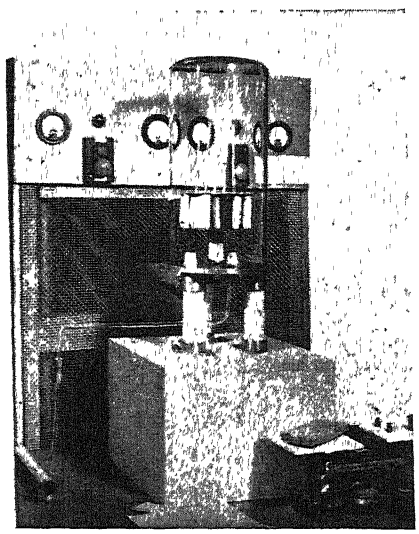
Electronic Processing

Through the Use of Such Electronic Processing Agents as Radio-Wave Components, Supersonic Waves, X-Rays, Ultra-Violet Rays, and Infra-Red Rays, New Methods of Producing Desired Physical and Chemical Changes in Materials Have Been and Are Being Developed by Industry

By JOHN MARKUS
Associate Editor, Electronics

ELECTRONIC control of processes such as baking, drying, hardening, annealing, painting, and gluing has progressed far in recent years, and the first era in the application of electronics to industrial processing of materials is ended. Now we are entering the second era, in which the invisible electronic agents are themselves doing the processing. The accompanying tabulation identifies these electronic particles and rays with a few of the material-changing jobs that they are actually performing today in industry.

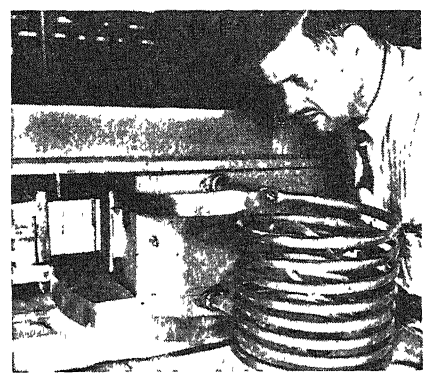
The manner in which things entirely invisible can do the work of baking ovens, paint brushes, chemical agents, and nature itself affords a series of stories best told by describing typical industrial applications in each category. With the attention of the entire world devoted to food problems today, the role of electronics in processing food materials logically comes first.



Test set-up used by Federal Telephone and Radio Corporation for dehydrating, by dielectric heating, food samples which have previously been compressed. To expedite removal of water, the space within the inverted bell jar and surrounding the food samples is evacuated

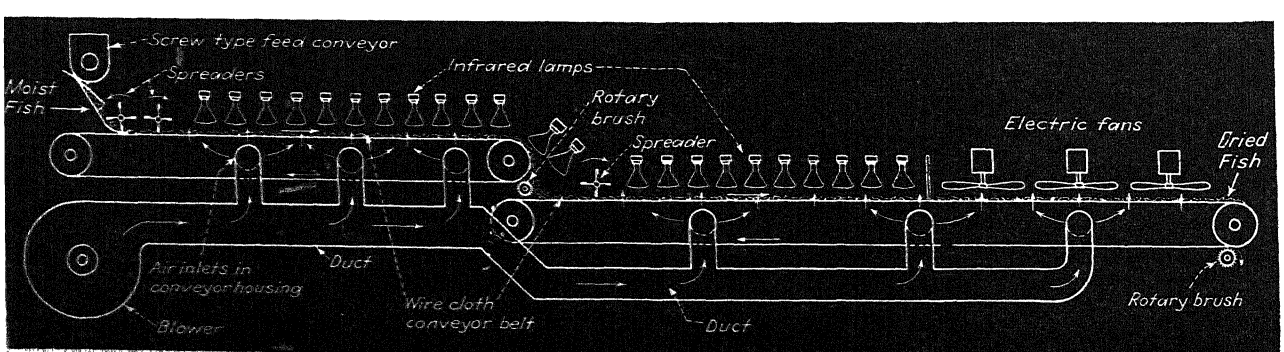
One of the latest developments in electronic processing is the use of radio-frequency energy for dehydration of food. With this process, the removal of 99 percent of the moisture content is achieved without injury to compressed vegetable blocks. Older processes permitted the efficient removal of only about 95 percent of the moisture, leaving enough to permit the formation of mold. Reduction of moisture content below 5 percent by previously used means often produced "case-hardening," a toughening and blackening of the skin of the product. Vegetables that have been dehydrated by the electronic method do not exhibit this deleterious effect and are not expected to deteriorate for a period of one to two years.

COMPRESSED FOOD DRIED—The electronic dehydrating process consists of placing compressed blocks of food between metal plates so that the food becomes the dielectric of a condenser. The metal electrodes are connected to a vacuum-tube generator of high-frequency energy. Losses occur in the dielectric of capacitors and, since the food material is not a good dielectric, considerable heat can be generated in it by the molecular friction caused by the rapidly alternating electric field. Heating of the food takes place from the inside outward to the surface of each block in much the same manner as a diathermy treatment heats the interior of the human body. Food dehydration is thus performed by the same means as is employed for dielectric heating in industry for gluing wood together, heating plastic preforms, and doing a host of other difficult heating jobs.



An electronic heating unit in use in a Fairchild aircraft plant for drying glue between wood strips. Intense high-frequency fields are applied to strip-clamping plates

Dehydration of milk by the conventional processing method removes some 90 percent of the water content and produces a powdered product that has adequate storing qualities in temperate



Simplified diagram of an infra-red unit for drying shredded salt cod in a continuous operation

climates but that does not stand up well in the tropics. Further dehydration of this product by electronic means removes all but 1 percent of the water content and provides a powdered milk that withstands tropical heat and humidity, yet can be readily converted back to a palatable liquid by the addition of water.

Some of the foods that have been successfully dehydrated so far by dielectric heating are shredded carrots, beets, cabbage and onion flakes, and riced potatoes. Roasting of coffee beans and other materials and controlled burning operations may also be accomplished by the vacuum-tube equipment. Results of the electronic processing so far employed indicate that very little, if any, adjustment of the equipment is necessary during processing periods. Operators need no technical knowledge of the electronic apparatus.

Shredded salt cod-fish is another food that is benefiting by electronic heating. About 60 percent of the residual moisture left by the method of natural drying can now be removed. Reduction of the moisture content to 43 percent is necessary for freedom from possible deterioration in warm climates. For this purpose infra-red lamps, which give out radiations whose frequency is between that of radio waves and visible light rays, are being used in one fishery

LONG WAVELENGTH LIGHT—The flaked salt cod is passed under the infra-red lamps on a wire-cloth belt while air is blown through the flakes to carry away the moisture and cool the fish. This use of long wavelength light has resulted in more speedy drying of the fish flakes, as well as a better product, than when the formerly used cabinet dryer was employed.

Other food products that have been successfully dehydrated by infra-red radiations are sweet potatoes, turnip greens, carrots, and precooked beef and pork. With these and other materials the radiant heating produced by the infra-red method owes its success largely to the high rate of heat transfer that is obtained as compared with conventional hot-air ovens.

Supersonic waves, or sound waves of such high frequency that they are inaudible to most human beings, hold promise of an increased number of applications in the post-war period. These sound waves can be generated by a vacuum-tube oscillator that is connected to a quartz crystal. This crystal then converts the high-frequency electrical alternations into mechanical vibrations and radiates energy in the form of intense inaudible sound waves. The sound waves so produced have been found particularly applicable to the processing of liquid materials in which rapid mixing of small particles, or emulsification, is required.

Other methods of producing these supersonic waves include the use of a metallic magnetic material suspended in the induction field of the coils forming the vacuum-tube circuit, so that the metal is free to vibrate at the induced frequency. Another method utilizes the same principle as that of the dynamic

Electronic Agents and Jobs That They are Doing in Industry

Infra-Red Rays

- Dehydration of beef, pork, and other meats
- Dehydration of sweet potatoes, turnip green, carrots, and other vegetables
- Drying of fish, such as salted cod
- Drying of precooked pork and beans
- Fast baking of paint on automobiles, tanks, lacquered bombs, and other painted objects moving on conveyor lines

Ultra-Violet Rays

- Sterilization of drinking water
- Tenderizing of meats
- Killing bacteria and germs in air and in materials, such as for prevention of contamination in handling blood plasma, pharmaceuticals, and foods
- Action on light-sensitive films and papers, as in photostat machines and in printing of movie film

X-Rays

- Activation of molecules of water and other solutions, making them unstable and highly chemically reactive
- Decomposition of dilute solutions of organic compounds, with liberation of carbon dioxide, hydrogen, and oxygen
- Oxidation of ferrous sulfate
- Activation of catalysts in presence of moisture
- Reduction of potassium nitrate
- Denaturing and flocculating of cell proteins
- Changing composition of genes and establishing mutations

Supersonic Waves

- Stimulation or destruction of bacteria in food products
- Production of smoother milk, ice cream, mayonaise, and other food products by emulsification, as in homogenization of milk
- Acceleration of the aging of wines and spirits
- Acceleration of chemical reactions
- Transformation of crystal structures
- Precipitation of smoke
- Transformation of chemical compounds
- Flocculation (movement into large aggregates) of suspended particles or gas bubbles in liquids
- Treating seeds to stimulate plant growth

Electric Fields—Charging Particles

- Charging abrasive particles with high vol ages produced by kenotron tubes, s points stand upright when abrasiv falls on the adhesive paper
- Charging particles of paint so they wi distribute themselves uniformly whe sprayed onto irregular-shaped charge objects
- Removing foreign particles, such as dus smoke, or pollen, from air by chargin the particles just before they pas through oppositely charged metal a tracting plates
- Suppression of smoke in ships, industria plants, or large buildings by chargin smoke particles and attracting them t charged collecting plates
- High-voltage sputtering of thin metalli films on surfaces

Electric Fields—Dielectric Heating

- Killing insects or larvae in grain, cereals on plants, and so on
- Roasting peanuts
- Popping corn
- Cooking steaks, hot dogs, and other meat uniformly throughout
- Toasting bread or buns
- Baking bread and other bakery products
- Baking ceramic products
- Heating rubber during processing
- Preheating pellets or blocks of thermoset ting plastic material prior to moldin
- Drying lumber, textiles, paper, and othe materials under controllable condition
- Drying glue in laminated wood product such as aircraft propellers and struc tural plywood parts of airplanes
- Providing uniform heat during certain processes of converting chemicals int cloth
- Curing plastic objects after molding

Magnetic Fields—Induction Heating

- Hardening surfaces of crankshafts, gears and other steel objects
- Flowing a 30-millionth inch thick layer o tin uniformly on steel strip to give a smooth surface without pinholes
- Annealing local portions or all parts o steel objects
- Driving out gasses from metals, as in de gassification of vacuum-tube elec trodes during evacuation

speaker contained in radio receivers, but employs a metal bar as the vibrating member in place of the parchment cone. This latter device is also proving quite successful in the flocculation and removal of suspended particles in smoke and fumes for the United States Bureau of Mines

The electrostatic charges that make people jump when they touch a metal doorknob after walking across a rug on a dry, cold day are being put to use in two radically different ways, both of which improve the quality of their respective products. In the manufacture of sandpaper, the abrasive particles are first intentionally charged to a high voltage, so that all have the same kind of charge (either negative or positive). The adhesive paper is pulled over a metal table that is charged continuously at this same high voltage and of the same polarity. Since like charges repel, and since the charges on the abrasive particles are strongest at the sharpest points, the particles all aline themselves with their sharpest points upward as the abrasive material is sprinkled on the moving paper. The result is a much sharper, faster-cutting sandpaper. The voltages for both charging jobs are produced by rectifying tubes known as kenotrons, which change alternating current to direct current.

ELECTRONIC PAINTING—Another application of electrostatic charges is in spray painting of irregular objects. The object and the particles of paint are charged in such a way that the paint is deposited uniformly on all surfaces, no matter how deep the irregularities in the shape of the object. A better job, in less time, with less paint, not only improves the quality of the processing operation but also reduces its cost.

Still other applications of electrostatic fields include smoke precipitators for chimneys and air cleaners for locations where dust, pollen, or other foreign particles in the air are undersirable.

In laboratories throughout the world, other electronic agents have also shown definite adaptability in producing physical or chemical changes in materials. Thus, with the high-speed neutrons of atom-smashing cyclotrons, any of the 92 known chemical elements can be changed into at least one other element by bombardment of atoms, and radioactive forms of every element can be produced. These radioactive materials can be used in place of radium, with greater safety, greater ease of control, and lower cost. Already, artificially radioactive phosphorus has been administered internally to patients in the treatment of leukemia, and radioactive iodine has been used to carry radiations to the thyroid gland.

In these and a host of other processing applications, then, electronics now offers definite improvements to speed and improve the final production of needed materials. Many other applications are undoubtedly also in actual use but under restrictions of military secrecy so that they will not become generally known until after the war. And for the future, electronic processing promises entirely new materials, improvements of existing materials, and speeding up of present processing methods with resulting lower prices

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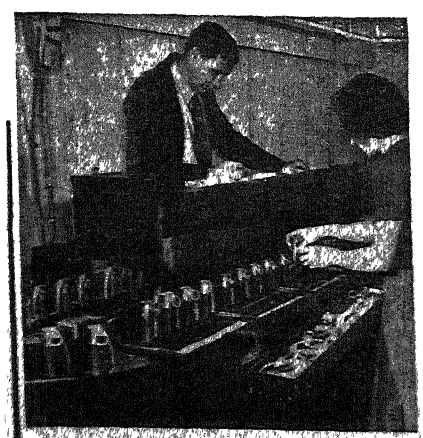
HAND-GRENADE FUSES

Checked for Correct Powder Content

THE ELECTRON-TUBE family tree is a large one. Each of the many kinds of tubes is able to operate successfully on its own, or, when desired, it can be used in co-operation with other members of the family. Amplifiers, rectifiers, photo-tubes, X-ray tubes, thyratrons, and any of the other kinds of tubes will form effective co-operating agents when industry so desires.



Bomb fuses, placed in cylinders on a belt, are carried through the X-ray machine where charge is checked

A dab of red paint shows on the improperly charged fuse, which was also detected on the meter graph

An excellent example is the joining of hands by photo-tubes and X-ray tubes in an automatic arrangement for checking to see that hand-grenade fuses have the correct amount of powder in them. In this equipment, developed by General Electric engineers, the fuse assembly, consisting of a metal tube containing two powder charges and a slow-burning fuse, is placed in a cylinder on a moving belt. The belt carries each fuse past an X-ray machine which looks into the situation to see how much powder is inside the assembly. A glow appears upon a fluoroscopic screen and a photo-tube measures the amount of light If the powder charge is correct, nothing happens.

But if the powder is too scanty to do a good job, lots happens: A bell rings to summon an attendant; a red light flashes; a daub of red paint is smeared on top of the defective fuse and the reject is recorded on a meter chart

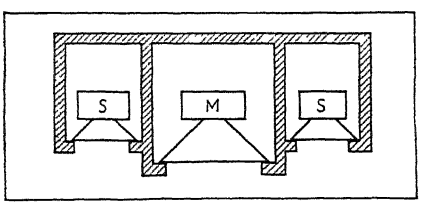
This combination of two electron tubes will test 4000 fuses an hour.

LOUDSPEAKING TELEPHONE

Eliminates Use of "Talk-Listen" Switch

TWO-WAY loudspeaker telephone service between two or more locations, so that persons conversing may speak and listen at a distance from the apparatus without operating the usual "talk-listen" switch found on other intercommunicators, is obtained by using an acoustically balanced combination of speakers at each station to overcome acoustic feedback and resultant howling.

Each station in the system is arranged with three loudspeakers. One of these is employed as a microphone, and is placed midway between the other two which have their voice coils connected in parallel and out of phase with each other. When one speaker impresses a portion of a sound wave of increased air pressure on the microphone there will be an equal and opposite pressure, or decrease in a sound wave, on the other speaker This results in cancellation of the two waves and therefore no net movement of the diaphragm of the microphone. A perfect balance cannot be obtained in practice but a considerable degree of cancellation of the sounds issuing from the two speakers is thus effected and howling due to feedback through the system is virtually eliminated.



Mounting the loudspeakers (S) and microphone (M) of the new intercommunicating telephone in separate padded compartments prevents practically all backside radiation effect

The speakers and microphone are mounted in a cabinet, each unit separated from the others by a partition. The remaining space in each enclosure is partly filled with sound-absorbent material so that the backside radiation of sound from the speakers is largely absorbed.

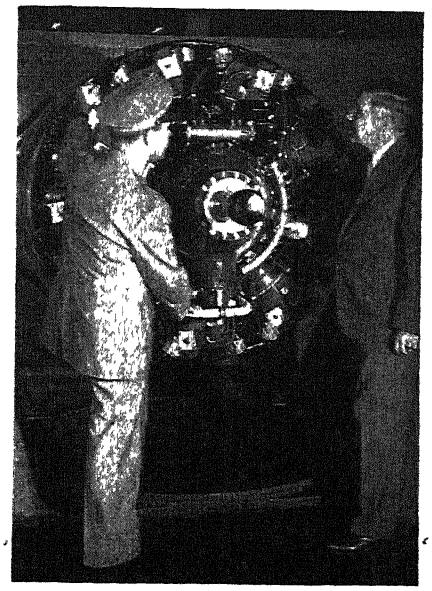
Engines of The Air

Highly Reliable Power-Plants have been Developed for Military Aircraft. These Will Have Direct Influence on Net Only the Future of Private and Commercial Flying, but on Engines for Automobiles. The Helicopter Poses Power-Plant Problems of its Own

EVEN THOUGH many war-time developments are still shrouded in mystery, the present status and future possibilities of the aircraft engine are becoming a little clearer. Outstanding engines, the war-time culmination of many years of development work, have done much to secure supremacy in the air for the United Nations. They will assure commercial and private flying of the post-war period of one essential—a highly reliable power-plant. Methods employed in their manufacture have led to advances in processing, materials, and tolerances which have aided and will continue to aid many other branches of American industry. And the efficiency, lightness, and power possibilities of aviation engines will undoubtedly have their influence on the post-war automobile.

The United States has led the way for many years and is still leading in the design of radial air-cooled engines. Now Wright Aeronautical has brought out the Cyclone "18" with the highest horsepower figure (2200) which the War Department has ever permitted to be published. The "18" is more powerful than the Cyclones which power the Flying Fortresses and is now in quantity production for heavy bombers, fighters, and transports.

The steady and rapid increase of the power output of aviation engines has not been due to the introduction of striking novelties, but rather to engineering development and refinement, made possible by clever technical brains, a world of experience, and unlimited funds and equipment at the disposal of manufacturers.



Lt. Col. Carl R. Borkland, A.A.F., and Myron B. Gordon, vice-president of Wright Aeronautical, inspecting the powerful, complex Cyclone "18"

The Cyclone "18" is not very different in appearance from previous models. But despite its tremendous power the engine has a diameter of only 55 inches—the same diameter as that of the original nine-cylinder Cyclone which was introduced in 1927 with a rating of only 525 horsepower. The engine has passed a special 150-hour run and extensive flight tests. Its 18 cylinders are built in two banks of nine cylinders each with a total displacement of only 3350 cubic inches Information in specific military installations is still restricted, but it is known that the Cyclone "18" has made its first transport appearance in the Lockheed Constellation, a 60-passenger high-speed transport.

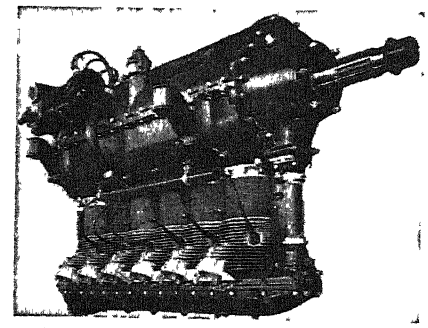
DESIGN FEATURES—Despite the lack of revolutionary principles in the new engine, there are still some splendid features in the design. Thus the nose section is so designed as to permit a close-fitting cowl and to reduce head resistance. A steel crankcase permits more power to be derived from the engine than does an aluminum crankcase. Magnesium is used liberally to keep the engine light, and the specific weight is just a fraction over one pound per horsepower—an extraordinary figure when it is remembered that a good truck engine weighs at least 11 pounds per horsepower.

Since the Cyclone "18" will power high-altitude military aircraft, it is equipped with a two-speed, gear-driven supercharger. To absorb the vast power of the engine the big propeller is provided with very broad blades, and to keep the blade-tip speed well below that of sound, the propeller is geared down to less than half crankshaft speed.

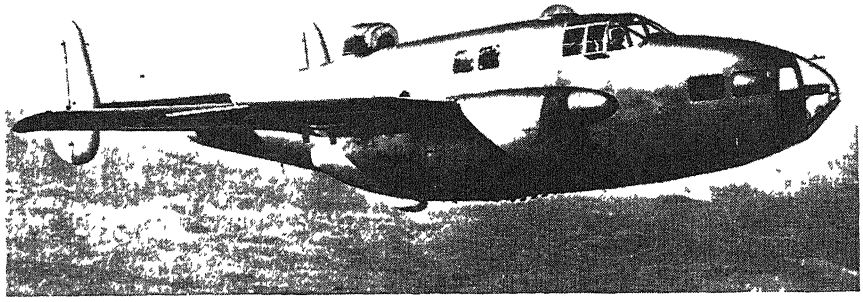
The development of such powerful engines will help commercial aviation greatly in the post-war period and these air-cooled engines already have helped to produce the fastest and most maneuverable tanks in the world.

Not only are engines of immense power being built; engineers are also finding various means of supplementing their power in emergencies. The Germans are said to employ special "dopes," fuels which, injected into the engine, increase its power for a brief emergency, though the engine is thereby completely ruined. Experiments are also being made with rockets or jet-propulsion engines which will give additional thrust for, say, half a minute and help to get an overloaded plane into the air. Auxiliary rockets or jet-propulsion means could also be conceivably used in flight when evading an enemy.

There is still another method of securing this momentary increase in power—a method developed by Pratt and Whitney Aircraft—which consists of injecting water into the cylinders of the 2000-horsepower "Double Wasp." The application of water-injection in aviation was first studied by Pratt and Whitney engineers only about a year ago, and proved so successful that thousands of conversions are now being made and installations are being undertaken on the Republic P-47 Thunderbolts. The water injection device has three advantages First, the cooling effect of vaporization in the cylinder is greater when water is added than with fuel alone. Second, the susceptibility to detonation which limits the power that can be taken from the cylinder is lessened by the presence of water in the cylinder. Third, it is said that more power is produced because the device permits the use of a leaner mixture from the carburetor. This is but one of many devices and improvements which the war has brought into being in



The six-cylinder in-line Ranger air-cooled engine: Neat and reliable



The Fairchild "Gunner", powered by two Ranger 12-cylinder inverted engines

the airplane engine; a number of them will be helpful in the post-war period.

Because the radial engines have been so successful and have powered such famous aircraft, it is likely to be imagined that they are the only type of air-cooled engines to be reckoned with. Nothing could be farther from the truth. The six-cylinder in-line Rangers, manufactured by Fairchild Engine and Airplane Corporation, have made a splendid reputation for themselves. These in-line engines offer a smaller nose and perhaps less head resistance than the radials and, at the same time, avoid the plumbing difficulties of the liquid-cooled engine. They have proved highly reliable and efficient and are now being manufactured at a satisfactory rate. The inverted six-cylinder in-line Ranger illustrated is capable of supplying 175 to 200 horsepower and is a neat and reliable product.

LARGE IN-LINE ENGINES—There does not seem to be any reason why the in-line principle cannot be applied to much larger engines, even though the specific weight may be a trifle greater than that of the radial. The V-type 12-cylinder Ranger, developing 500 horsepower, indeed has made an enviable reputation for itself. The neat appearance of the Fairchild "Gunner" is in some respects due to the engine. This speedy mid-wing monoplane carries a power-driven turret, is built of plastic-bonded plywood and is designed as an advanced training ship for our aircraft gunners.

Some remarkable engines are now available for the private plane, ranging from 50 to 200 horsepower, beautifully constructed, reliable, much cheaper than anything we could have expected a few years ago. They are doing fine duty in military and naval training planes and in the Civil Air Patrol; they are ready to equip the thousands of private planes which will be in the skies soon after the war is ended. A fine example of the low-power engine is the Continental A Series type, comprising four air-cooled cylinders, horizontally opposed, ranging from 50 to 80 horsepower, and from 170 pounds to 176 pounds in weight. These engines are particularly interesting in that they are equipped with fuel injection, which makes for better fuel distribution, eliminates carburetor or manifold icing, and reduces fire hazards.

Another fine example of an engine for private flying is the Kinner Model R-540-3. The Kinner five-cylinder engines range from 100 to 175 horsepower and are used in a variety of Army and Navy trainers, at fields both in the continental United States and abroad.

The point to remember about the light engines is that, while they may be heavier in pounds per horsepower, they are in every way as refined and as reliable as their bigger prototypes. Manufacturers such as Wright Aeronautical and Pratt and Whitney have perhaps led the way but certainly the builders of smaller engines have known how to follow and in a few respects to lead the big two engine companies.

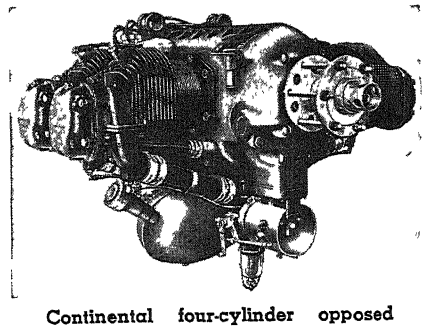
There is one question which a discussion of the modern aviation engine, however brief, should not neglect: What about engines for the helicopter? So far as we know, no special engines for the helicopter have been built as yet, and perhaps no special helicopter engines are needed. But there will most certainly be decided modifications or adaptations of the conventional aviation engines to fit them specifically for helicopter use. Thus, L. A. Majneri, Chief Engineer of Warner Aircraft Corporation, believes that engines for operating helicopters (where the axis of rotation is vertical) should be arranged to have their crankshafts vertical. That would mean that the aircraft radial engine would be disposed in a horizontal position with its driveshaft above and the accessory drives below.

We can perhaps add to Mr. Majneri's views on the adaptations or modifications necessary. It is much more difficult to cool an engine installed in the helicopter, because this type of aircraft may be called upon to hover or to climb vertically, thus receiving practically no cooling air. Therefore, the helicopter engine must be provided with a cooling fan, placed quite close to the cylinders, and, for preference, the fan should be built into the engine itself. Again, the helicopter engine, like the automobile engine, must be provided with a clutch and a free-wheeling or over-running device, because at times the rotor must be free to auto-rotate. When the engine fails suddenly the rotor must be disengaged at once from the engine.

Another requirement is that the engine shall have a high speed of revolution, say 2400 revolutions per minute, while the rotor of the helicopter functions best at a low speed, say 250 revolutions per minute or even less. Hence a powerful gear reduction must be interposed between the two.

A number of writers have raised a plea for integral aircraft power-plants; that is, an aircraft engine which would be self-contained when installed in the airplane. There is still more reason why the power-plant for the helicopter should be an integral one and contain within itself the clutch, gear reduction, cooling fan, and over-running device. A real opportunity presents itself here for the engine builder, particularly for ingenious mechanical designers in general.

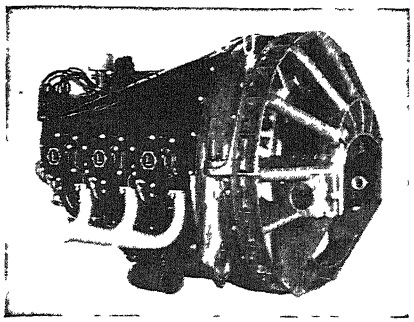
INFLUENCE ON OTHER ENGINES—The air-cooled aviation engine itself will also influence other types of engine construction and, in particular, that of the automobile. We have secured authoritative opinion in this regard. Thus Mr Majneri, whom we have quoted previously, is quite positive that the air-cooled engine will be re-introduced into the automobile. Re-introduction is the correct word when we remember that for many years the Franklin automobile was equipped with an air-cooled motor and enjoyed much popularity. Of course, it will probably not be the radial air-cooled engine that will be used in the automobile but rather the in-line or opposed-cylinder engines, which obviously lend themselves better to installations in the motor car. The cooling of such engines would be by fan, just as in the helicopter, since the automobile also is at times deprived of a cooling air stream. The specific output of these engines would be in the 50- to 150-horsepower range, the range which will also be the most interesting for the private airplane.



Continental four-cylinder opposed type engine for private planes

We have frequently had occasion to comment on the extreme lightness of the aviation engines. This lightness of the aviation engine will certainly have its repercussion on the automobile engine of the future and will cause aluminum and magnesium to be used more freely than heretofore in the automobile power-plant. But the automobile engine will nevertheless weigh more per horsepower than does the aircraft engine; weight saving is not at such a premium in a surface vehicle.

Continental Motors tells us that one of their light four-cylinder opposed engines of the aviation type will be prominent in a low priced automobile, but they withhold further information. No doubt other companies building light aviation engines today have similar



Derived from aviation practice, this Lycoming "packaged power" unit is designed for surface-vehicle use. The large blower at right provides air for cooling

plans. Lycoming Division of Aviation Corporation is more definite in its information and states that it has developed a self-cooling "packaged power" unit of 162 horsepower, intended for surface vehicles and definitely a derivative of aviation experience. The motor is well worth study. It has a dry weight of 755 pounds and develops 162 net horsepower at 2800 revolutions per minute on 73-octane fuel. It is designed for enclosed or submerged installation. The principal element of the cooling system is a cast aluminum fan or blower mounted integrally with the flywheel and having an outside diameter of 28¼ inches. The 16 blades of the flywheel have an airfoil shape. Half the air cools the engine, half supplies slightly supercharged power to the carburetor.

This "packaged power" unit is a direct relative of the standard Lycoming aircraft engines, with such modifications as battery ignition substituted for the aircraft magneto and the addition of clutch, fan, air baffles, and the like. Reduction in specific weight and immunity to temperature extremes are but two of many advantages which this neo-aircraft engine will bring to the service of surface transportation

EDITOR'S NOTE: *This is the first of two articles on airplane power plants by Dr Klemin. The second article will cover other phases of the subject, including high-altitude flying and jet propulsion methods and possibilities.*

* * *

TOUGH PLANES

Prove Their Ability to Withstand Abuse

REPORTS appear frequently in the press of Flying Fortresses which limp home with hundreds of bullet holes in wings or fuselage, with engines almost shot away, and the like. Some have asked whether our combat airplanes, bombers, and fighters are really capable of taking such terrific punishment and still bringing their crews back to safety. The answer was well presented recently by Major General Delmar H. Dunton, in an address before the Society of Aeronautical Engineers, who drew on his experience with the Air Service Command to give an authoritative and encouraging picture.

In the General's opinion, the United States is building the finest fighting aircraft in the world, not only for offense but also in their ability to stand up under punishment We quote his views as regards ability to withstand enemy fire. "Our airplanes have flown home beaten up and smashed to an extent that even the most sanguine of us never dreamed an airplane could be damaged and continue to fly We have seen in the past few weeks at least two photographs . . . showing two of our battle craft winging their way homeward after having been badly beaten in combat. I happen, personally, to have seen and inspected both of these airplanes. One is the B-17 F which had its tail almost completely severed."

It appears that a ME 109 attacked the Flying Fortress and struck the fuselage at its juncture with the fin, the left wing of the German airplane plowing through fin and fuselage The impact swung the fighter around so that its propeller chewed completely through the left horizontal stabilizer and elevator of the B-17. The pilot of the Fortress felt the shuddering impact, yet managed to fly his ship back to the edge of the desert. Similar incidents related by the General all give an impression of extreme toughness in American planes

BIRD-LIKE EYES

Needed by Post-War Civilian Fliers

WITH THOUSANDS of persons planning to buy the promised post-war inexpensive airplanes, a new field of human activity will be opened up that will require more efficient eyes than those which have guided motorists in the past, says M. J. Julian, president of the Better Vision Institute.

"Birds have the sharpest, keenest eyes of all creatures, including man. They need such eyes," says Mr. Julian. "Post-war civilian aviators must strive for bird-like eyes. They will have to train and tune up their sight if they are to avoid the fate of Icarus.

"Civilian fliers will find new conditions of seeing in air motoring. On land it is possible, even with inefficient eyes, to judge distances and speeds by objects along the route of travel, but in the air those guides will be lacking, or are to be seen only remotely in new perspective. A land-lubber taking to the air easily might misjudge the distance, speed, and direction of another plane.

"In operating automobiles, millions of persons have been very neglectful of their eyes. Instead of keeping them tuned up to top efficiency, such persons have depended upon their brakes and the maneuverability of their cars to dodge hazards. But planes have no brakes comparable to the automobile's four-wheel brakes. Also, because of the nature of flying, it will be hard to change in a split second the course of a plane traveling 100 miles an hour.

"In land motoring visual acuity, or sharpness of vision, is the principal concern of traffic officials in respect to eyes of drivers. That also will be important in the air motoring of the future. But other visual factors must receive greater attention," continues Mr. Julian. "Among these are eye coordination, muscle balance, and depth perception. The condition known as aniseikonia, in which the images in the two eyes are of different size, promises to be important. Studies indicate that this defect is not rare. In aniseikonia the eyes find it hard to see on a level line. This condition tends to cause a flier to tilt his plane in cruising and landing Instead of bending mud-guards, an aniseikonic flier probably would break wings when landing."

SELF-STARTING TIRES

Reduce Rubber Wear When Airplanes Land

WHEN the airplane first strikes the ground, the landing wheels are not in rotation. Therefore, for a few instants, the tires slide along the ground instead of rolling; the resulting landing-impact wear shortens the life of the tires Impact-wear becomes all the greater when the plane is heavily loaded and lands at a high rate of speed.

It has often been suggested that wheels should be set into rotation before impact, and a variety of complicated devices have been presented to achieve this purpose. Now Henry F Schippel, of the B. F. Goodrich Company, has invented a pre-rotation method which requires no electric motor and is very simple. All that is required is a series of vanes or fins built into the side-wall of the tire When the landing gear of the airplane is lowered, the vanes catch the air and set the wheel spinning. Moreover, the

Fins pre-rotate landing wheels

fins, made of rubber and fabric, are so constructed and placed that they fall back into a position flush with the side of the tire on the "upper half" of each rotation of the wheel. Thereby the effectiveness of the device in spinning the wheel is greatly increased, and it is quite possible to have the wheel spinning at the full speed of the airplane itself when it touches the ground.

Besides reducing tire wear, pre-rotation makes the landing smoother.

Chicago's New Subway

Fluorescent Lighting, Piston-Action Ventilation, Reversible Escalators, Automatic Drainage, and Complete Operational Safety are Some of the Outstanding Features of this New Transit System Designed to Relieve Traffic Congestion in the Famous "Loop" Section of the City

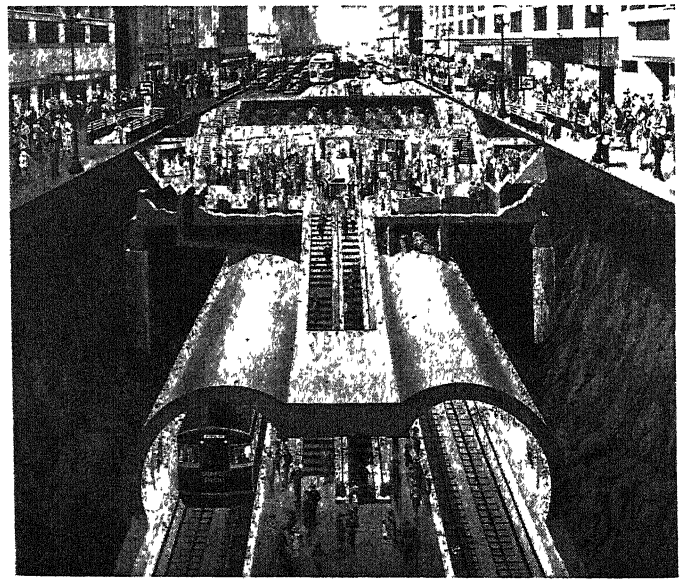
PROFITING by the latest advancements made in the safety, comfort, and operational efficiency of underground railway design and construction, the recently completed State Street subway in Chicago is proving its worth as an indispensable transportation unit in that city's vast network of transit lines.

Although conceived originally as an aid to relieving the badly congested traffic conditions in the famous downtown "Loop" section of the elevated rapid-transit lines, this modern transportation facility incorporates many conveniences for its patrons. For example: Escalators furnish effortless access to and from the loading platforms at train level; automatic ventilators provide fresh air and control temperatures within the subway; fluorescent lighting creates a cheerful atmosphere; automatic block signals of latest design insure the safety of train operation.

The State Street subway is a deep-level, twin-tube design, carrying one track in each tube. Construction was started in December, 1938, carried through to completion despite priority restrictions, and the subway placed in operation on October 17, 1943. Costing $34,000,000, this 4.9-mile section is the first of four units to be completed in the city's proposed subway system, which eventually will embrace 55 miles of line at a cost of some $275,000,000. A federal grant of $18,000,000 was secured at the start of construction, the remaining funds being furnished by the City.

Tunneling was employed in much of the subway construction to minimize interference with normal street traffic, although some open cut was made for installing tubes adjacent to the portals. An unsafe, soft soil was encountered in the downtown area, requiring heavy shields and the use of air pressures up to 15 pounds per square inch gage. Tunneling, hand-mining, and multiple bench methods were employed in the outlying areas. Two basic types of tunnels were used; a horse-shoe shaped section for the bench method and a circular section for the shield method. Heavily reinforced concrete walls form the completed tubes.

Where the subway passes beneath the Chicago River, a twin-tube, concrete-lined, prefabricated steel tunnel was sunk in a trench below stream bed to avoid excessive grades in the subway profile Considerable shoring and underpinning was required for some of the large buildings located adjacent to the subway, while careful excavation and street decking were necessary in the construction of the subway stations.



Stairs lead from sidewalk entrances of the Chicago subway to mezzanine stations; escalators and stairs lead to platforms

Making the connections between the old elevated structure and the ends of the new subway was a complicated procedure, requiring considerable remodeling of existing supporting towers and bracing. The general plan was to build an inclined structure on the ground at each tunnel entrance, carrying a sand-filled roadbed retained by concrete walls. These inclined structures connect to the tunnel portals and slope up to connect with steel inclines at their upper ends. The steel inclines, in turn, connect with the old elevated tracks.

It was desired to maintain the existing three-track and four-track elevated lines running into the downtown loop section from the south and from the north. Consequently, at the junction with the incline connections, the old tracks were spread apart, forming double track run-arounds at one location and one single track and one double track run-around at another. These elevated tracks return to their original locations at points where vertical clearance permits the subway trains to pass beneath them. Since new steel was at a premium, as much of the old steel as possible was remodeled on the site to serve in the steel deck and supporting towers of the inclined structures.

Trains from the elevated tracks are routed either onto the inclines or the run-around tracks by an interlocking system of track switches and crossovers operated by compressed air and controlled from interlocking towers at each end of the subway. Train operations are carefully controlled at all times both in the subway and at the elevated line junctions by the most modern of safety methods known in railway operation. For example, interlocking machines located in towers adjacent to the inclines have a control board on which is mounted a miniature diagram of the interlocking plant's switches, tracks, and signals. Small electric lights behind the diagram indicate a train's exact location at all times as it approaches and moves through the plant The plant operator sets up the route for each train by manipulating various buttons, thus causing the switches to be automatically positioned and the block signals to be cleared.

Within the subway tubes, train operations are controlled by a modern block signal system that includes wayside colored lights, approach interlocking signals, and other automatic safety signals found only in the most modern systems

One of the most important safety devices is the system of electro-pneumatic train-stop mechanisms located at each automatic block, approach, and home signal. Should any train run past a red light at one of these points, this train-stop mechanism engages trip arms on the train, instantly setting its air brakes. The train can not then proceed until its motorman manipulates a stop-release mounted nearby Automatic train stops and all track switches at interlocking plants are operated by compressed air delivered throughout the subway under a pressure maintained at 65 pounds per square inch.

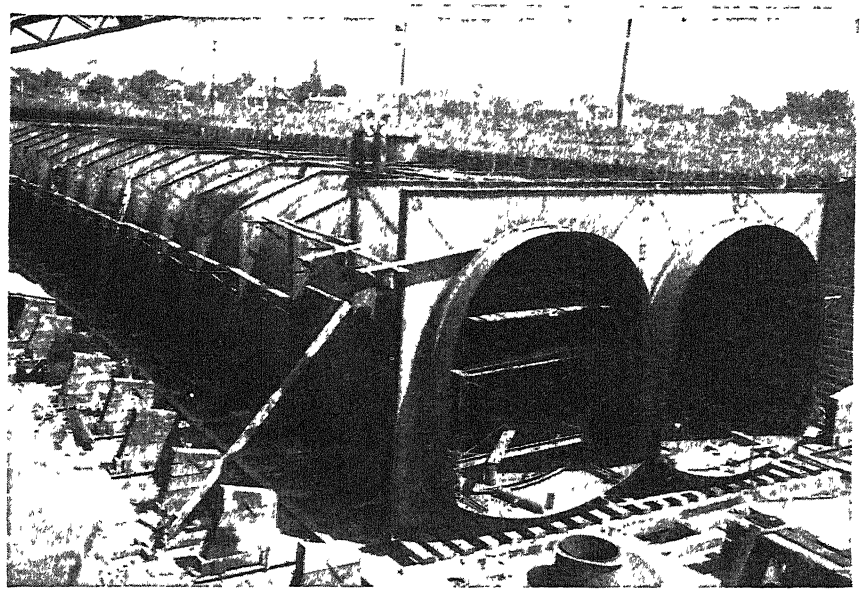
Safety was paramount also in designing the subway's power system Motive power is the same as that used for the elevated lines, namely, 600-volt direct current on the contact (third) rails, with parallel feeders and with a return to the substations through running rails. A heavy third rail, weighing 144 pounds per yard, permitted reduction in the amount of copper required in the feeder rails. Contact shoes on the trains are of the suspended over-running type, while the contact rails are supported on porcelain insulators, with expansion joints every 1000 feet.

EMERGENCY PROVISIONS—All contact rails are sectionalized at interlocking plants and at various feeder-point locations. Emergency alarm boxes are spaced 400 feet apart along the subway walls. Switches within these boxes can be thrown, in the event of a train wreck or other emergency, thus de-energizing the contact rail. Another safety feature is a continuous emergency walkway built at car-platform height along the tube walls. Circular stairwells at frequent intervals along the walkways lead to emergency exits at street level. Covers on these exits are equipped with panic-hardware to insure positive operation.

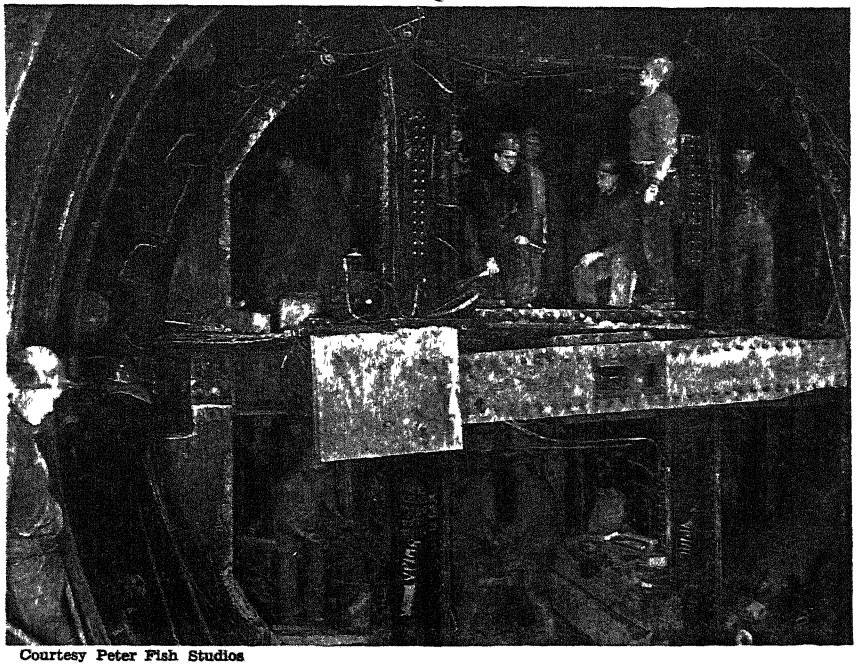
Any water entering the subway through vent shafts, stairwells, portals, or other openings is removed by ten pumping stations. Each installation has a drainage sump below track level and two pumps, one of which serves as a standby for emergencies. Submerged centrifugal pumps are driven through long shafts by a 208-volt, three-phase squirrel-cage splash-proof motor automatically controlled by float switches. Where the subway passes underneath the Chicago River, the motors are located at ground level, operating pumps below by 80-foot shafts. Motors are equipped with line-voltage starters and they range in size from 5 to 50 horsepower.

Ventilation of the subway is obtained chiefly through the piston-action of moving trains. Chief reason for subway ventilation is to expel the excess heat generated by the electrical operation of trains and other equipment, and not for supplying fresh air within the tubes and stations, as is commonly believed. Taking advantage of air pressure created by moving trains—whose cross-sectional area is about one half that of the tubes—vent shafts were installed from track level to street grade. As trains move through the tubes, they suck in large quantities of air through the vent shafts, at the same time forcing out equal amounts through others. A total of 69 of these vent shafts are installed in the State Street subway.

Vent shafts adjacent to subway stations serve the double purpose of providing ventilation and blast relief for loading platforms from the air pressure of onrushing trains. Electrically operated fans provide ventilation during emergencies and for ventilation at the river crossing. In addition, they supplement the piston-action in the downtown stations. There are, in all, 26 of these huge fans capable of furnishing an additional one million cubic feet of air per minute.



Sections of prefabricated tunnel that now carries the subway under the Chicago River

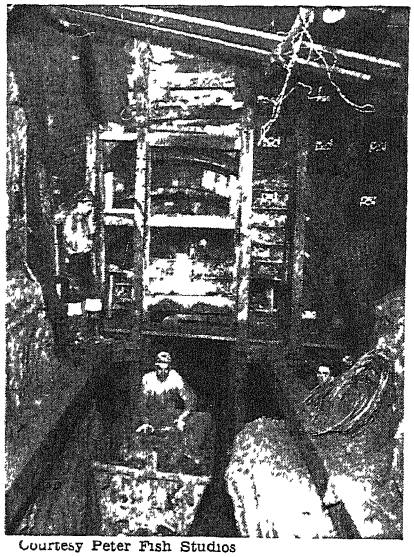


Courtesy Peter Fish Studios

Part of the tunnel excavation was carried out by the circular shield method

LIGHT ASSURED—One of the most striking features of modern subway construction is the fluorescent lighting used throughout the subway stations and loading platforms. The Chicago Subway is a pioneer in this type of subway lighting. An independent incandescent system lights the tubes and provides emergency lighting for the stations Duplicating alternating-current supplies energize the fluorescent lighting system In addition, a separate limited system is fed from the 600-volt, D.C. traction power system through a light main extending the entire length of one tube In the event of a power failure in both the incandescent and fluorescent lighting systems, automatic transfer switches will tap power from the third rail, lighting a small number of lamps, sufficient for emergency operation of the subway.

An atmosphere of comfort, cheerfulness, and efficiency is displayed in the attractively designed subway stations They are of the mezzanine type and are located between the subway roof and street level. Each outlying station has a 500-foot loading platform at train level to accommodate a train of eight 60-foot cars. Some platforms are centered between the tracks while others are loca-



Courtesy Peter Fish Studios

Hand mining methods were used in some of the tunnel sections where the nature of the soil permitted

ted on the outer side of each track.

Eight mezzanine stations are located in the downtown section between Congress and Lake Streets, one centrally located in each city block and all connected by a 3430-foot continuous island platform between the two tracks. Short stairway entrances lead from sidewalk level to the mezzanine stations, while reversible escalators and stairs lead on down to the loading platforms 40 feet below street level. Mezzanines are finished in a glazed tile and structural glass, with exposed columns encased with radio-black marble. Cashier-controlled and coin-operated turnstiles, a general facilities room, open phone booths lined with acoustic metal, rest rooms, and a concessions booth complete the mezzanine station facilities

COLOR-CODED STATIONS — Directional signs, steel columns, and terra-cotta trim for the loading platforms are finished in four basic colors—blue, red, green, and brown—and rotated in the order named to assist the commuter in identifying his destination. Platforms and mezzanine floors are of red concrete to which alundum was added to provide a non-slip surface. Stair treads are fitted with abrasive tile to prevent slipping.

Modern trains could not be secured for subway operation because of priority restrictions. This necessitates the use of existing steel cars of the Chicago Rapid Transit Company until they can be replaced by modern equipment. However, 455 of these units are available; 389 being equipped with two 170 horsepower motors, and 66 being trailers. Each car will seat 52 passengers and has a total capacity of 100.

The State Street subway was designed and built by the City of Chicago's Department of Subways and Superhighways, under the supervision of Philip Harrington, commissioner, with Ralph H. Burke and Charles E. DeLeuw serving as chief engineers. Joseph D'Esposito was project engineer representing the interests of the federal government

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HIGHWAY CONSTRUCTION

Program for Post-War Is Biggest Ever

A POST-WAR highway program developed by the American Road Builders Association indicates that highway construction after the war will be the largest ever undertaken in this country.

One of the principal recommendations of the report is that a construction program totalling three billion dollars per year be undertaken for a period of five or six years following the war. This is twice the size of the previous record highway construction program which ran close to one billion five hundred million in 1930

CONCRETE TANKS

Lined for Safe Storage of Gasoline and Oil

MORE than 2000 concrete storage tanks of 25,000- to 2,500,000-gallon capacity are included in the Navy program for storage of gasoline and oil. According to Navy spokesmen, the problem of porosity of the concrete, which permitted seepage of the stored liquid, has been largely overcome.

The Navy, in co-operation with industry, has developed various types of linings for the inside of the tanks, which, in effect, form a big envelope containing the stored fuel and keep it from seeping through the concrete.

For heavy fuel oil it has been found that all that is necessary is to paint the inside of the concrete tank with sodium silicate (water glass), four coats giving a satisfactory cover.

For Diesel oils and gasoline, three different types of lining materials have been developed. One is a vinylite plastic, painted on the interior of the tank. Another is sheet Thiokol, cemented to the interior. The third type consists of Thiokol in latex form in a layer of cotton fabric.

TEST BUILDING

Provides Many "Climates" for Mechanized Equipment

CLIMATIC conditions varying from those in the humid tropics to the freezing Arctic regions may be simulated in a laboratory building recently completed for the testing of Army mechanized equipment, according to *Engineering News-Record.*

The "hot" and "cold" rooms in this building, some of which are large enough to accommodate 60-ton tanks, will permit studies on the effect of extreme weather conditions on both men and machines.

The laboratory is housed in a 54- by 110-foot reinforced concrete frame structure, two stories in height. It is air-conditioned throughout by means of a seven-zone summer and winter system.

The "cold" room, which has a 28-inch-thick floor, 20-inch walls and ceilings, and 12 inches of cork all around, provides temperatures down to 60 degrees below zero, Fahrenheit.

The "hot" room has thinner walls, insulated with mineral wool. Here temperatures up to 150 degrees, Fahrenheit, in combination with humidities as high as 95 percent, can be produced.

PLYWOOD GIRDERS

Offer Advantages for Building Construction

GIRDERS with plywood webs and timber flanges are now being used extensively in the Middle West.

Many advantages are claimed for this new product, which has been used on over 80 projects. Ad antages include· (1) fabricatio.1 in a shop, which permits rigid control of manufacturing processes and assures maximum strength of members; (2) the girders are rigid, deflection being less than 1/360 of the span at 1200 pounds per square inch extreme fiber stress; (3) lumber demands are low and the material required comes in stock sizes; (4) girders are easy to erect, which permits rapid field construction; and (5) few strategic materials are required

As shown by the accompanying photograph, the web consists of a single thickness of standard fir plywood with the outside grain vertical or at right angles to the flanges. The latter, both top and bottom, consist of solid or laminated members of stock fir lumber on each side of the web. The flange timbers are glued to the web and at intervals dowels are added to assist in the distribution of the stress. A diagonal timber tension member, which is added at each end of the girders to transfer the tensile stresses from the lower to the upper flange," eliminates the necessity of thickening the webs at the ends of the beams to resist shear. The girders are designed for spans varying from 10 to 60 feet

This new application of wood for structural purposes has been developed by Timbeam, Inc

A plate girder with plywood web

Casting's Progress

War Needs Have Intensified the Application of Modern Science and Engineering in Foundry Practice. Now Castings of All Types Have Better Properties, Can Be More Efficiently Manufactured, and are in the Best Competitive Position in Their History

ABOUT the only good effect which wars have on society is the sharp acceleration of technological progress they produce. Thus when we hear of the tremendous strides made in foundry engineering in recent years, it is natural to credit the Martian influence for most of this advance. The wartime transformation of the foundry industry has indeed been considerable, but actually the fundamental changes in foundry practice wrought by the introduction of scientific and engineering methods antedated the war, the latter serving chiefly to spread their influence much more rapidly.

"The foundry industry" is that industry which specializes in the manufacture of castings—metal products made by pouring liquid metal into molds roughly approximating the shape of the finished product. Broadly speaking there are six types of foundries, if classified according to the metals they cast: Gray iron, steel, malleable cast iron, non-ferrous (in the foundry field this term refers to brass and bronze), light metals; and heat- and corrosion-resistant alloy castings.

According to *Penton's Foundry List* there are some 4800 foundries in operation in this country, of which 2890 make gray iron, 600 steel or alloy castings, 126 malleable cast iron, 2620 brass and bronze castings and 2040 aluminum or magnesium castings. In actual weight of delivered castings the gray iron branch of the industry is the colossus, its production being in the neighborhood of 14 million tons annually. Steel castings added up to about two million tons in 1943, "malleable" about one million, and the total of brass, bronze, aluminum, and magnesium about two million.

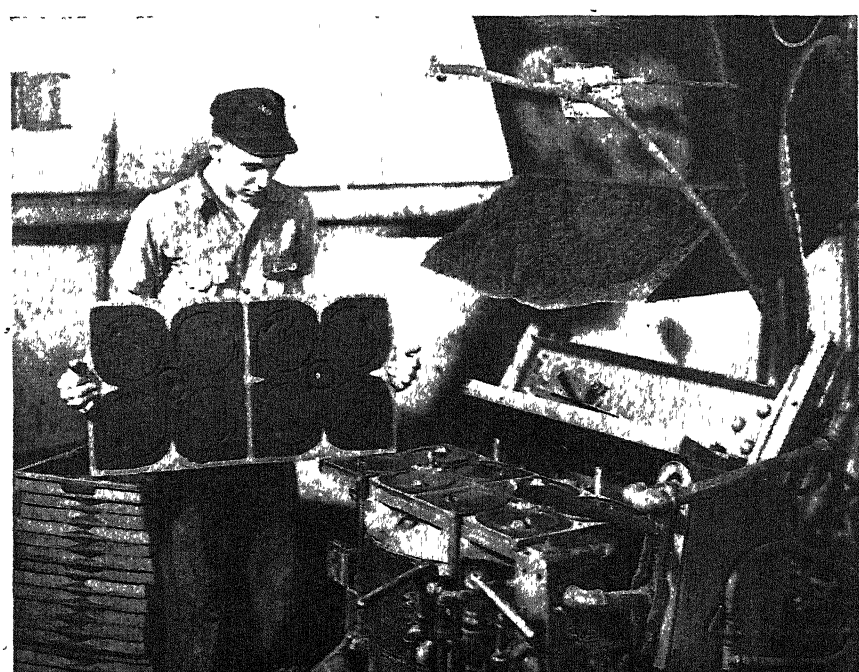
If foundries are backward technically (as is widely believed) then such backwardness is almost a fundamental flaw in our industrial structure. If, however, the foundry industry is progressive (as is actually the case); if it utilizes new scientific concepts and modern engineering practice; and if it has provided its own solid base of forward-looking research and development, then we may expect its influence in the American scene to grow and the market for castings to expand continuously.

Although the products of different foundries may be quite unlike, metallurgically, and tend to find different types of application, the various branches of the industry are strongly bound to each other in the similarity of methods and techniques they employ and in their common marketing problem of presenting the casting as a competitor with forgings, die castings (not usually considered foundry products) welded structures, and other forms.

Because of this, "foundry engineering" today is an actuality and the average foundry is no longer a rule of thumb, by-guess-and-by-gosh, handcraft shop. A frequently remarkable level of product quality and operating efficiency is fast becoming the rule (although the exceptions are still too numerous, in the minds of industry leaders).

RECENT OUTSTANDING ADVANCES in foundry engineering have been in five general directions. (1) the metallurgical improvement of product quality and soundness through the use of modern refining and alloying methods and the application of scientific knowledge of the internal structure of metals; (2) the development and application of specially effective casting processes and molding practices such as centrifugal casting, duplexing and triplexing, plaster molding, directional solidification, and blind risering; (3) the use of "sand control" to improve the surface and internal quality of castings through scientific formulation, treatment, and testing of mold and core sands; (4) the general mechanization of foundry operations, including conveyorized pouring of molds and mechanical handling of sand for conditioning treatment and reclamation; and (5) the employment of the latest quality-control tools — X-ray and radium inspection, the metallographic microscope, pyrometric control instruments for melting and pouring temperatures, spectographic analysis for raw material and finished casting composition control, and so on.

The application of foundry engineering has been well distributed throughout all branches of the field. It is not slighting the others, however, to say that the steel castings and light metal castings manufacturers have embraced modern methods and metallurgy in the greatest proportions. On the other hand, the most notable single trend in the whole foundry field in recent years has been the steady improvement in the engineering quality of gray iron castings



Courtesy American Hammered Piston Ring Division, Koppers Coke Company

Molds made in this pneumatic molding machine have controlled moisture content

made by the average well-managed foundry, and the extraordinary betterment of properties achieved by a smaller number of plants using special processing techniques.

Gray iron is today a material of construction on a par with wrought iron or cast steel for many applications, and superior to it for some. Gray iron is essentially an alloy of iron and more than about 2 percent carbon, with part of the carbon present as graphite flakes. Whereas the average grade of gray cast iron several years ago was called a "weak and inherently brittle material," with a tensile strength of only 15,000 to 25,000 pounds per square inch and few structural or load-bearing applications of importance, today iron of more than 30,000 pounds per square inch tensile strength is common and 50,000-pound iron is the regular product of many foundries.

Although cast iron has a lower ductility than most wrought and some cast materials this fact is of much less importance now than formerly, for the best-informed engineers are today convinced that ductility has been highly over-rated as an essential engineering property, especially for scores of applications involving no tensile loading. But beyond all that, modern gray cast iron offers a unique combination of wear resistance, machinability, capacity for absorbing vibration, and good compressive and tensile strengths that have recently caused many to revise their estimates of its potentialities as an engineering material.

HIGH-STRENGTH IRONS—As evidence of this are many successful wartime applications of high-strength irons for which cast iron would have once been considered quite unsuitable. Diesel engine crankshafts, cutting tool shanks, milling cutter bodies, marine propellers, turbine runners, shell forging dies, rubber-machinery parts, gears and bearings for mobile anti-aircraft guns, hand grenades, and so on, in addition to many machine-tool parts, are now being made as iron castings—some of them specially-processed trade-named irons like Meehanite, Sorbo-Mat, or Proferal, and others unbranded products of equally enlightened foundry practice—and testify to the engineering serviceability of current cast irons.

This steady improvement in strength and quality of gray iron has been achieved through several developments and practices—"inoculation" of the molten iron in the ladle; the use of weighed, dried, or heated air for blowing the hot metal in the cupola; superheating of the molten iron; the incorporation of alloys in the composition to increase strength or hardenability; and the heat treatment (including flame hardening) of cast irons. Many of these practices have stemmed from one basic, only-recently accepted principle: That the properties of cast iron are determined as much by its internal structure, and especially by the size, shape, and distribution of the graphite flakes dispersed in it, as by its composition expressed as total carbon content.

Thus "inoculation" involves the addition to the molten iron of small amounts of calcium-silicide, ferro-silicon, graphite, silicon carbide, silicon-manganese-zirconium, or other agent which cause the graphite to begin forming while the metal is liquid rather than after it has solidified. Thus it produces an ultimately finer and more uniformly distributed graphite-flake dispersion. Superheating and control of cupola air (air-weight control, hot blast, or dry blast) have, among other things, a strong effect on the rate of formation of the graphite and therefore on the structure and properties of the iron.

The incorporation of nickel, chromium, molybdenum, and other metals in gray iron has strengthened and toughened many of today's iron castings or has made them more amenable to heat treatment in heavy sections, so that heat-treated alloy irons may have tensile strengths exceeding 50,000 pounds per square inch. But the demand for these is comparatively small and the gray iron industry's major contribution to ultimate Victory has been its expanded production of high-strength (40,000 to 50,000 pound) irons that contain no critical alloying elements, but which derive their excellent properties from the engineering or metallurgical techniques previously mentioned.

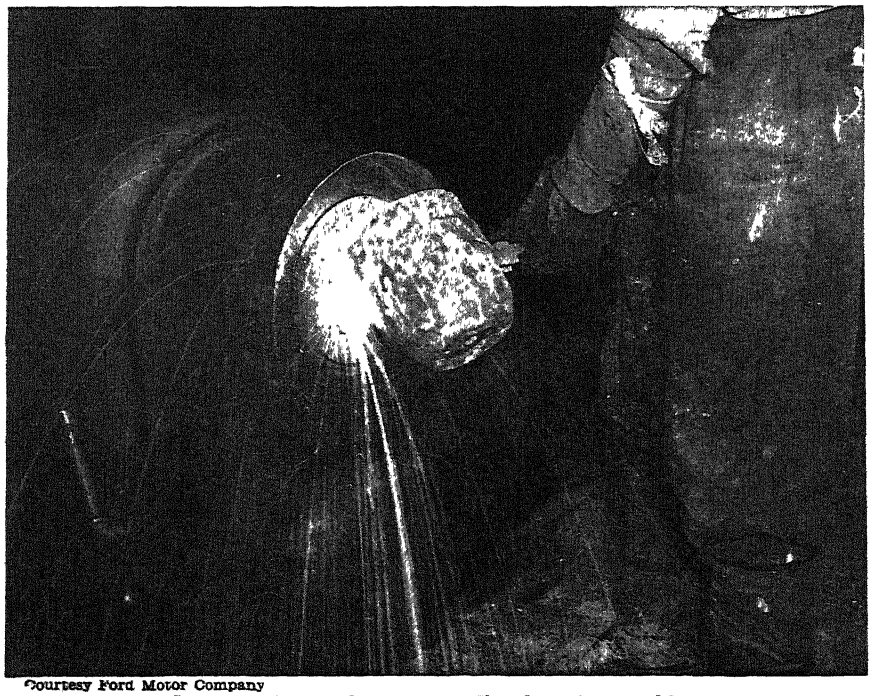
Of all types of foundry products, steel castings have been the most heavily applied in ordnance. For example, the M-4 medium tank, which weighs some 60,000 pounds, contains steel castings to a total of 29,000 pounds, of which 20,000 pounds represents the weight of the one-piece cast armor hull. In fact, the applications of steel castings everywhere in war production have multiplied so rapidly as to necessitate an expansion of the industry from a production level of about one million tons in 1940 to more than two million tons annually at present.

Simultaneously, engineering advances in steel-casting manufacture have come with breathless rapidity. Normally lavish in their use of alloys, steel foundrymen have learned to produce castings of the highest quality with percentages of alloy content formerly considered much too low. Better melting and molding practice, the use of centrifugal casting, and the intelligent application of liquid-quench and temper heat treatments are some of the reasons for that achievement.

Fascinating indeed is the story of centrifugally cast steel and its mushrooming application for products that once could be made only from steel forgings or other wrought products. In centrifugal casting the molten metal is poured into spinning cylindrical molds, which may spin on either a vertical or horizontal axis and may be made of either metal or sand. The centrifugal force of spinning gives the equivalent of a pressure casting, uniformly dense and sound, with inclusions and the unsound portions confined to the easy-to-machine-off inside diameter of the casting.

CAST STEEL USES—The demonstrated high strength, ruggedness, and service reliability of such centrifugally cast steel products as artillery gun barrels, aircraft engine cylinder barrels, automotive brake drums, heavy-duty gears, ship shafts, welding flanges, retort tubes, and so on, have opened new application-possibilities for this still-young metal form, and have given a mental lift to many steel foundrymen who are wondering what post-war use they might make of their war-swollen capacity for producing steel castings

Steel castings as a product of the "side-blow" converter, once considered of little safe utility for the production of high quality castings, have in the last two years become a regular part of the industry's output. The now-accepted use of the converter followed two stimuli: (1) experimental demonstration by two Batelle Memorial Institute men that converter castings could be every bit as good as those made in the



Courtesy Ford Motor Company

Pouring alloy steel into a centrifugal casting machine

Courtesy Wright Aeronautical Corporation

Making a mold for casting an aluminum cylinder head for an aircraft engine. Long nails are inserted into the sand to act as reinforcements during pouring of the metal

open hearth or electric furnace, and (2) the development of "duplexing" processes whereby the gray iron founder's cupola is used to melt down steel scrap and pig iron, and the carbon, silicon, and manganese are blown out in the converter to produce a satisfactory steel. Such processes not only permitted the rapid production of badly-needed steel castings with only a minor investment in new equipment as compared with the cost of new open hearths or electrics, but also found ready use for many cupolas that would otherwise have stood idle, to the financial embarrassment of their owners.

Refining and alloying of the duplexed metal may conveniently be done in an electric furnace which, when added to the cycle, transforms the process into "triplexing." In addition, the electric furnace frequently serves as a "holding" furnace, acting as a reservoir of hot metal to which molten steel can be added and from which it can be drawn continuously to supply conveyorized molds on a mass-production line.

The application of the so-called "directional solidification" concept has markedly improved the soundness of steel castings and has even permitted the production of castings once thought impossible. Directional solidification involves the controlled speeding of solidification in some regions and the retarding thereof in others through various devices, so that the inevitable shrinkage cavity will occur in the top of a riser (an external, removable appendix to the casting) and not in the casting proper. Allied to this is the very recent expanded use of blind risering or atmospheric-pressure feeding, whereby a sand core (most recently, a graphite wedge) is inserted through the cope of the casting into the top of the riser, which is otherwise enclosed in sand. Hotter feed metal and cleaner, sounder castings are the customary result.

A CHALLENGE MET—Malleable cast iron foundry engineers have met the challenge of war production under extremely trying circumstances, particularly an acute shortage of manpower. The most notable contribution of malleable has been its widespread use to replace highly critical brass or bronze castings or steel forgings in ordnance equipment.

The long annealing cycle in malleable iron manufacture, normally requiring *days* for completion, has been shortened to *hours* in some foundries through the use of a short-cycle practice involving controlled atmosphere furnaces instead of packing the parts in pots filled with solid material. "Pearlitic malleables" (or more accurately "arrested-anneal malleables"), which are short-cycle products combining some of the properties of cast steel and of ordinary malleable, have enjoyed a remarkable increase in wartime application.

The most recent advance in the malleable iron field is the use of tiny amounts of boron (about 0.001 percent) to increase the amenability to annealing of malleable irons containing stray alloy contents introduced via the scrap used in melting.

High mechanization—the use of conveyorized pouring lines and of semi-automatic core-making and shakeout equipment—has been intensively applied in the manufacture of aluminum and magnesium castings. Cast alloy compositions (aluminum-magnesium-zinc alloys, for example) have been developed that require no heat treatment to develop mechanical properties comparable to those of the high temperature precipitation-hardened alloys. The aluminum foundries have learned to make high-grade castings out of secondary metal, and this alone is an achievement of real importance under today's conditions.

The use of plaster-molding processes for making precision castings both in light metals and in brass is finding increasing favor. By means of the process, tolerances approaching those possible with permanent (metal) molds can be achieved, yet without the cost of making metal molds. Applications have been confined to relatively short-run jobs and many have involved conveyorized handling.

The outstanding recent metallurgical developments in brass and bronze castings manufacture have been (1) general realization that the atmosphere in which the metal is melted and refined should be slightly oxidizing *rather than reducing* to promote maximum freedom from porosity and (2) development of secondary metal refining methods and casting metallurgy that permit the use of large amounts of secondary ingot metal (made from scrap) in castings manufacture without significant sacrifice of general engineering quality.

Centrifugal casting and plaster-mold casting have both been applied with striking success for copper alloys and are certain to continue in important use in the post-war period.

Among the broadest trends in the entire foundry field has been the astonishing increase in knowledge of the effect of mold- and core-sand mixture compositions and treatment on the surface finish and internal soundness of all types of castings and the application of that knowledge practically everywhere. Type of sand, moisture content, clay content, and type and amount of binder are all regularly considered in sand formulation. Core-baking temperatures are closely controlled. The use of resin core binders, which require lower baking temperatures and are more readily shaken out, is being endorsed by more and more foundries. Such binders also permit the re-use of core sand without expensive reclamation equipment.

The foundry industry is basic in our industrial economy. It has successfully met the shock of war, continued to improve its technological level and will enter the post-war period better able to meet the competition from wrought products than ever before in its history.

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GERMAN ALUMINUM ALLOYS

Have Reduced Copper Use to Vanishing Point

Among the closely guarded wartime secrets of America's metallurgical experts are the compositions of two or three new ultra-high-strength, heat treatable aluminum alloys. Each of the leading aluminum producers has developed at least one and they have been making outstanding contributions to faster, more powerful aircraft.

The Germans haven't been idle either, in this field. Faced with a copper shortage that makes *our* copper stringency look like super-abundance the Nazis have sought to eliminate the metal from alloys wherever possible. The most common strong, heat-treatable aluminum alloy "duralumin" (17S and 24S in this country) contains 4 percent copper, so German metallurgists have brought forth a new substitute aluminum-base material containing 4.5 percent zinc, 3.5 percent magnesium, and no copper, which is said to be at least the equivalent of duralumin for aircraft construction.

Variations of the alloy in use also contain chromium and manganese for additional strength. Tensile values are over 55,000 pounds per square inch. (The new American alloys give strengths considerably higher than that.) Best results are obtained by heat treatment comprising heating to 750-925 degrees, Fahrenheit, quenching in water, and allowing to age-harden at room temperature.—*From the German journal "Aluminum."*

PRECISION HARDENING

Made Possible By Use Of High-Temperature Quench

Typical of recent heat-treating developments that have speeded production or assured the maintenance of necessary precision without prohibitive time or expense is the application of isothermal or constant-temperature heat treatment to the hardening of small projectile or other ordnance parts.

(Continued on page 134)

Measuring Roughness

hen the Motor and Aviation Industries Put Stiffer Demands on Bearings, mething More Scientific had to be Substituted for the Machinist's Eyes d Fingertips. Using Instruments Having a Stylus Point to Draw Across a rface, the Roughness is Measured in Millionths of an Inch

By HARRY B. SHAPER
The Brush Development Company

NLY in the past 10 years has the concept of surface roughness obned a scientific meaning. Various ethods of judging surface roughness d been used by the early craftsmen. e fingertips or thumbnail slid gently er a surface are remarkably sensitive surface irregularities. A trained invidual can detect the difference beeen a perfectly smooth surface and slightly rough surface whose roughss is below the level reached by opal microscopes. The optical microope can magnify surface irregularities they are larger than the wavelength

FIG. 1

Even an irregular surface like this may appear to be shiny and smooth. But the shine comes only from the parts between the irregularities

the light used, or approximately wn to 1/200,000 inch for ultra-violet ht. While the fingertips are sensitive, gertip estimates of roughness still will ry over a range of 10 or even 100 to depending upon different individuals. A second method of judging roughss was an optical method. Judgment smoothness was based on the mirrore quality of a surface. This led to ny erroneous estimates of smoothss, since many surfaces which exhibit dull gray finish may actually have aller deviations from flatness than e which is shiny and mirror-like. us a surface which has been burhed would present to the eye an apently polished appearance. This type surface on a piston, as shown in Fige 1, would soon chip and score the lls of the cylinder.

The qualitative methods of judging faces—that is, those just described—ke down as soon as the automobile l aviation industries began to search methods of carrying large loads at h speeds on small light-weight bears. Automobiles had to be brought m high speeds to a dead stop with small brake drums in a short time. Airplane motors had to develop thousands of horsepower on shafts a few square inches in area. The life of engines at high speed had to be extended. Pistons and rings had to make millions of cycles without developing serious leakage of oil. Cams had to maintain accurate dimensions, to open and close valves in split seconds. For a while it was necessary to break-in engines and mating parts, a process which resulted not only in considerable inconvenience, but in a serious compromise in the permissible fit of parts. Large tolerances had to be allowed during the break-in period so that the mating parts would not freeze together. Consequently, the still larger clearances which existed after break-in resulted in short life due to the extra slap of one rotating part against the other.

QUANTITATIVE PICTURE—The study of the nature of the surface which gave the best over-all performance for load-carrying capacity and long life showed that the roughness of the surface was important. Certain methods of finishing machine parts lead to longer life and shorter break-in periods. A quantitative picture of the nature of the different surfaces resulted in a set of characteristics for an ideal surface. It was found that, in general, for a given machining process:

1. The smoother the surface, the better.

2. Any roughness which existed should be of such a nature that the variations from true flatness should occur as depressions. Figure 2.

3. The surface should not be burnished or spun over in order to attain smoothness, but should be cut away without distorting the grain surface.

The above conditions are not the only conditions for obtaining optimum bearing surfaces, but are the most critical ones. If a surface has all its irregularities below the face, rather than some above and some below a median line, a larger area is available for load support. As shown in Figure 3, even small peaks in the surface can change its bearing properties

A committee on standards has set forth the following definitions for describing a surface.

1. *Lay.* The direction of the machining process. Operations such as grinding, boring, turning, always have two directions at right angles to each other with different micro-inch depth readings. Hand operations, such as lapping and sanding, have no preferred direction of reading. In addition, there are random finishing processes like super-finish, tumbling, and random polishing machines which also have no preferred direction.

2. *Waviness.* The general contour of the finished surface, which is usually of the dimensions of .04 inch or greater.

3. *Roughness.* The microscopic deviations of the surface.

Figure 4 shows the relations of 2 and 3, that is, of waviness and roughness.

The modern methods for measuring surface roughness are:

1. A stylus point rides on the surface in the vertical position and follows the contour of the surface. The deviations of the stylus tip are translated into electrical pulses, and these pulses are magnified and then either read by means of a meter or recorded on a chart to give a picture of the surface. Figure 5 shows a pole shoe and a diamond stylus. Both of these ride on the surface. The respective motions of the shoe and stylus generate electrical voltages Since the pole shoe follows only the mean height, and the stylus follows the fine deviations, the difference between the two amplitudes, converted into voltages, indicates the roughness of the surface. The pole shoe radius is made small enough so that if the surface is

FIG. 2

For load-carrying capacity and long life the variations from flatness should take the form of depressions

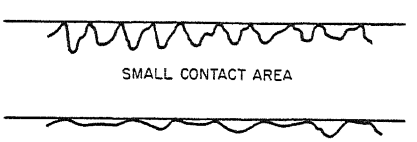

FIG. 3

Even small peaks in a surface, as is shown in the upper of the contours, can change its bearing properties

absolutely smooth but wavy (waves are considered to be larger than 04 inch) the stylus and the shoe will move synchronously and no voltage will be generated. Therefore the electrical reading is proportional to the roughness alone, and not to the waviness of the surface.

2. Another method of measuring surface roughness is to measure the reflectivity of the surface. A light source is reflected from the finished surface into a photocell A perfectly smooth surface can be set to give a definite reading; and then, as the surface gets

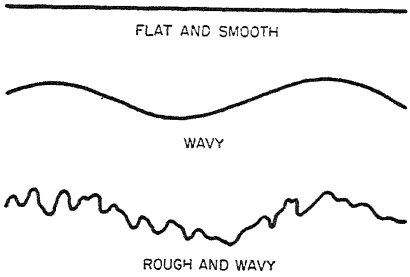

FIG. 4

Waviness and roughness are not synonymous, wavy irregularities being larger. A surface could have a wavy contour without roughness, or a rough contour without waviness

rougher, less light will be reflected into the photocell (Figure 6.) The ratio of these readings is then a measure of the roughness.

3. The taper method: The finished surface is plated. After a heavy plate is put on, the surface to be observed is sliced at a shallow angle, as shown in Figure 7. This shallow angle results in vertical magnification of the surface deviations, but of course gives no horizontal increase. Practical limitations in the grinding and polishing process limit the mechanical magnification afforded by this method to about 25 times. However, once this is accomplished, optical methods of observation become feasible down to fairly small surface deviations, although not as low as the stylus method permits. This method may be used to check the more rapid stylus method. Its very great disadvantage lies in the time required to investigate a surface and in the fact that it destroys the surface.

4. It is possible to measure the roughness of a fine surface in very great detail by using the electron microscope. An extremely thin layer of a suitable drying material is poured over the surface and allowed to dry. This layer is then peeled off, inserted into the field of the electron microscope and photographed. The hills and valleys then photograph respectively in light and dark areas. In spite of the necessary painstaking procedure, this method will be widely used in the future in research to investigate surfaces because of its fineness of detail.

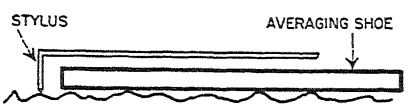

FIG. 5

In the stylus method of measuring surface roughness the stylus is drawn across the surface and its deviations are translated into electrical impulses which are amplified. At the same time a flat shoe traverses the surface and its deviations are separately translated into electrical impulses and amplified. The apparatus then automatically subtracts the small stylus readings from the larger shoe readings, and thus the desired roughness reading is sorted out from the less essential waviness reading

Of the four methods just described, the one used most widely is the stylus point method, and two of this type of instrument are sold commercially. One of them is the "Profilometer" made by the Physicist Research Company and the other the Brush Development Company's "Surface Analyzer" (Figure 8). With these types of instruments, deviations of one micro-inch (millionth inch) can be measured. When it is remembered that the separation between molecules of the material generally is in the order of .005 micro-inch, it is realized that the limit of measurement is pretty close to the ultimate accuracy possible.

Of course, different commercial companies argue for their own method of surface finishing, and the theories developed for the ideal surface are not yet fully substantiated, but all of us have noticed in the past five years a remarkable increase in the life of automobile engines. One of the surface-finishing processes developed is the "super-finish" method used on parts which have been ground down to their prescribed dimensions with fine grinding

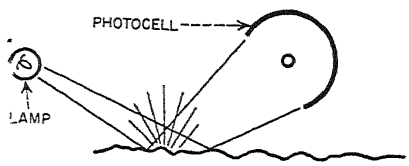

FIG. 6

A simple sketch illustrating the basic principle of the reflectivity method of measuring surface roughness. A perfectly smooth surface would reflect a maximum of the light into the photocell. The light is reflected elsewhere in proportion to irregularities

wheels. These parts are placed in a machine which uses soft and fine stones, flexibly mounted, which scrub the surface slowly and gently for a period varying from 10 seconds to about a minute. This scrubbing action, which is random, serves to cut away gently the sharp edges protruding from the surface, leaving only valleys in the material.

With this super-finish process, tolerances of the finished parts are maintained very closely, and only a small amount of break-in is required. The depressions serve, in addition, to retain oil wher oil is used between the mating parts.

The proponents of this finish have run some experiments showing that the rust-resisting properties of these finished parts on exposure are superior to those

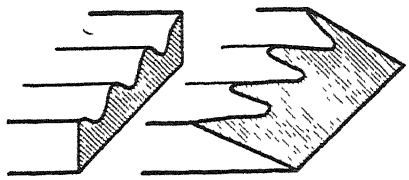

FIG.7

Illustrating the taper method of measuring surface roughness. Slicing the surface diagonally, as shown, magnifies the irregularities vertically

of other finely finished surfaces. This is understandable when we remember that, by finishing a surface to a great degree of flatness, the total area is actually decreased even though the bearing area is increased, and in addition the surface has no sharp corners where electrolytic action can occur with greater intensity.

As in the super-finish process, it has been found that, by taking a finely finished surface and gently sanding it with very fine sandpaper, the load bearing capacity of the material will rise two or three times, due to the increase in surface contact area.

In general, then, the reason for investigating the finish of a surface depends upon the fact that when two parts meet in a bearing or other working machine part, the largest area of contact possible will generally result in better performance. The reason for the use of soft bearing materials on one of the mating parts is that the soft material tends to fill the crevices in the hard material, and then the two parts mate more smoothly. The disadvantage of using a soft material, such as a Babbitt metal, is that the metal cannot support heavy loads without distorting.

OPTIMUM COMPROMISE—The requirement that all surfaces be finished to small micro-inch readings is complicated as soon as design and production cost come into the engineer's consideration. For example, when considering the design of automobile brake drums there is a choice between making the finish finer and making the shoe larger Making the drum larger so that it can conduct a given amount of heat generated requires space and weight. This results in higher material cost and a lower machining cost. Finishing the

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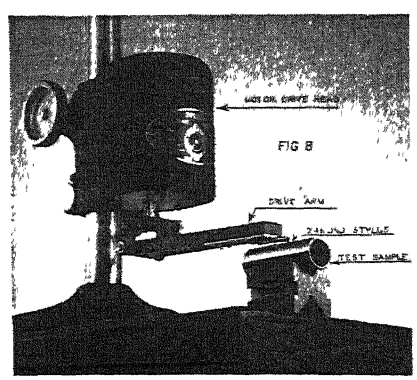


The Brush Surface Analyzer. Its motor-driven arm slides the stylus and shoe steadily across the surface

Keeping Business In Business

One of the Outstanding Stories of Materials Substitution to Grow Out of Metal Shortages is that of the Use of Fabricated Fiberboard for a Wide Variety of Applications. Refrigerators, Clothes Lockers, Lunch Boxes, Lighting Reflectors, and Toys are Only a Few of the Items Affected

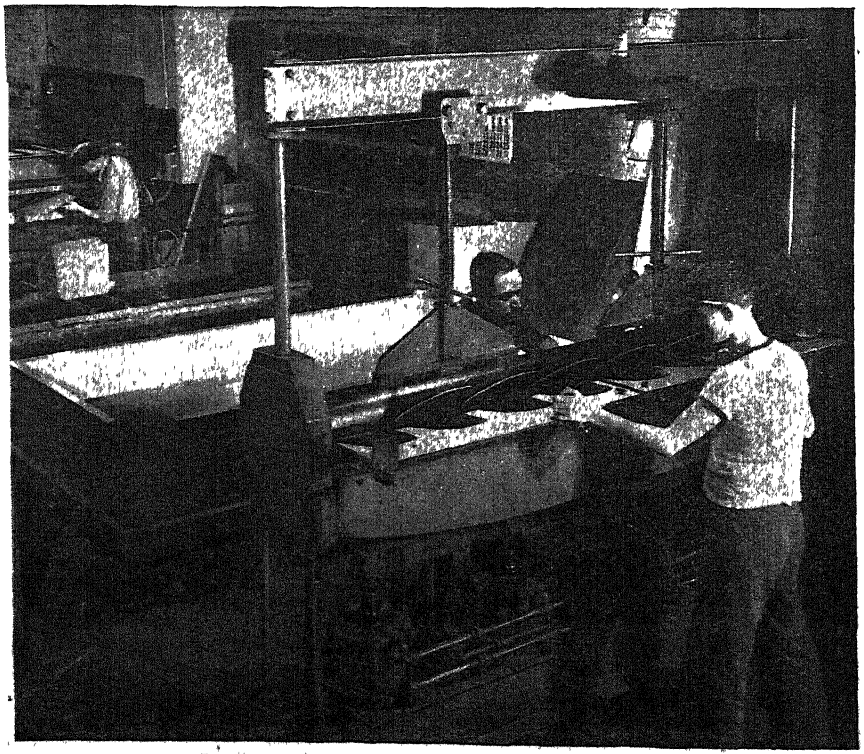
By A. P. PECK

DRASTIC orders which the War Production Board issued, curtailing the use of critical metals—steel, copper, aluminum, and various alloys—in the manufacture of civilian products, threatened to put innumerable companies, both large and small, entirely out of business. That many of these companies have survived and are now thriving, is the basis of a fascinating story of scientifically applied substitutions. While these substitutions have been carried out in many ingenious ways, one of the outstanding examples is the use of fabricated fiberboard as a replacement material for formerly used metals. In many cases where fiberboard has been so applied, it was found that production could be speeded up, often with savings in the final weight of the finished item and, in many instances, substantial savings in cost

Essentially the secret of the properties of fabricated fiberboard of the Masonite type lies in the two basic elements of natural wood. The tiny cellulose fibers of which wood is composed and the lignin which holds them together. From this natural material, through a process of "exploding" the wood, it is possible to produce a hard, strong board which lends itself admirably to a wide variety of uses in many fields.

When the wood is "exploded," the cellulose fibers are not damaged nor is the lignin removed. The "explosion" results in a mass of fibers of varying degrees of plasticity, which can then be interlaced and, under varying degrees of heat and pressure, be "welded" together into a board which shows properties of equal strength in all directions. In this process the lignin itself furnishes the bond.

From the fiberboard so produced it is possible to fabricate shapes of various contours, applicable to the production of a number of different manufactured units. Many such applications have been made and so successful have they been that it is probable many of them will continue in use after metals, in which the situation is even now easing, are once more available to industry in general.



Bending fabricated fiberboard to specified contours

A few examples of the uses to which fabricated fiberboard has been put will serve to indicate the possibilities of this material and perhaps to project a trend of the future.

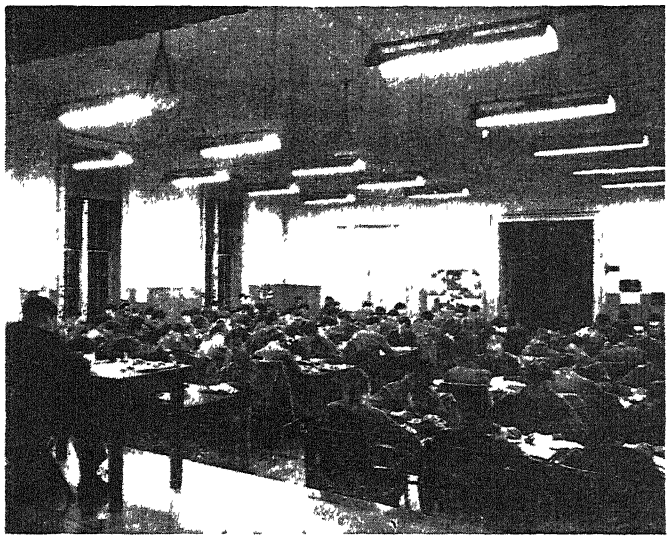
A steel refrigerator manufacturer was formerly using approximately 100 pounds of metal per unit produced. Today, however, restrictions dictate the use of a maximum of six pounds of steel per unit; fiberboard has been applied to make this enormous reduction possible. By fabricating the sheets to the desired sizes and contours and providing baked surface finishes, a refrigerator is now being produced which is stated to have all the glowing beauty and durability of the former models combined with the essential sanitary qualities necessary in refrigerators

When expansion of war plants called for an unprecedented production of lockers for the workers, a complete line of fiberboard lockers, wardrobes, and storage cabinets, were designed, using a minimum of critical materials. These overcome the objections to ordinary wood lockers because they provide fire protection, are resistant to moisture, have high strength and durability, permit flexible rearrangement and use with steel lockers that may already have been installed, and resist the absorption of food and other odors.

METHODS PERFECTED—Active in the work of fabricating Masonite has been Service Industries, Inc., who have perfected methods of handling and bending the material. One of the examples of work done by this organization has been the production of reflectors for fluorescent lighting. Good lighting is an essential in all types of industrial production, yet until only a short time ago metallic reflectors were considered essential to

such installations. And upon the contour and efficiency of a reflector depends largely the overall efficiency of a lighting system.

Starting with a maze of highly technical lighting problems, reflectors were designed to be fabricated entirely from fiberboard. In the course of this work a special plastic-impregnated board was developed Now, as a result of concentrated research, standardized fiberboard reflectors have the approval of the Underwriters' Laboratory, the War Production Board, and the Electrical Testing Laboratories. Some manufacturers are guaranteeing 85 percent efficiency for these reflectors, with actual efficiencies ranging up to as high as 89 percent. These efficiencies are considerably higher than those of porcelain-enamel reflectors.



Fiberboard reflectors for fluorescent lighting

In lighting fixtures of this type, efficiency of a reflector is not the whole story. Fiberboard reflectors show great savings in weight. The 40-watt fiberboard reflector weighs only five and one half pounds, the 100-watt reflector only ten pounds; whereas metallic reflectors of similar size weigh two to three times as much. Then too, the fiberboard is non-corrosive, retains its shape because of its rigidity and will not dent or kink as will metal.

In the field of blades for fans used for cooling and other purposes in industry, thousands of pounds of metal were formerly used Now blades are being made of fabricated fiberboard with efficiencies equal to those of metal blades. Furthermore, some people think that fiberboard fan blades are quieter in operation. Certain it is that many manufacturers who are using these new fan blades have found so many advantages in them that they will never return to the use of metal.

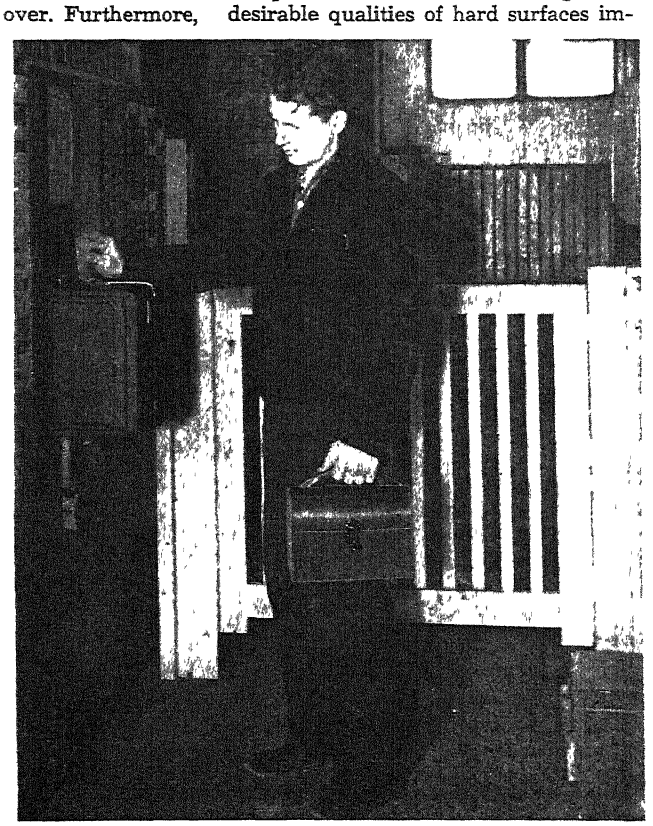
Steel wheels for baby carriages was another item hard hit by the restrictions on metals. Something had to be found to replace the steel and it had to be tough as well as resistant to rain, sleet, snow, heat and cold, and the shock of rolling over rough pavements The problem was solved by producing wheels composed of three laminations of fiberboard, machined and grooved for tires and axles. In the first few months of production more than 200,000 of these wheels were put into service. So far there have been less than half a dozen replacements, indicating that fiberboard wheels will outlast steel wheels many times over. Furthermore, the fiberboard does not require greasing and will not squeak even after long use. It is estimated that through the adoption of this laminated wheel approximately 180,000 pounds of steel have been released in one year of production.

The poultry industry was thrown into a sorry predicament when steel for the manufacture of chick brooders, nests, and feeders was restricted. The industry was being called upon to increase its production, yet the use of steel for vitally needed units was virtually prohibited. Into this picture stepped fabricated fiberboard to produce laying nests, brooders, and feeders that are not only satisfactory to poultry raisers but appear to be well liked by the hens themselves. It has been shown that the hens prefer fiberboard, probably because it is warmer in winter and cooler in summer

Another item for which there has been a tremendously increased demand by war workers is the lowly lunch box, formerly made entirely of metal. The newest lunchbox, however, is made almost entirely of fabricated fiberboard, except for the metal hinges and latch, with a plastic handle and waxed paper insert lining at the bottom of the box. It is made to fit a pint size vacuum bottle, weighs about two pounds, and can take an enormous amount of abuse.

DESIRABLE QUALITIES—To these and many other manufactured products, fiberboards such as Masonite and Tempered Presdwood have brought the desirable qualities of hard surfaces im-

Fiberboard has largely replaced metal in this refrigerator



A lunch box that uses metal only in hinges and latch

The desk lamp and correspondence boxes are fabricated of fiberboard

pervious to ordinary liquids, durability for years of wear, and resistance to chipping or cracking under impact.

The recitation of details could be extended almost indefinitely, but many of them would be repetitious of what has already been recounted. The civilian products fabricated wholly or largely from fiberboard now include, among others, such diversified items as desk lamps, children's toys, clipboards and filing equipment for offices, starch trays for the candy industry, fire-resistant stove boards to protect floors under domestic space heaters, card tables, ironing-board tops, kick and push plates for doors, and so on.

But civilian production has not been the only beneficiary of this work toward perfection of fiberboard as a replacement material. Similar applications have been made in war industries, notable among them being the use of the board for bench tops, production-line trays, bench bins, and the like.

Thus American ingenuity has come to the rescue of industry with a material and methods of fabrication which not only have served to contribute directly to stepping up war production in defense plants but have also helped many manufacturers to stay in business without a drain on critical materials

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RECENT notices in the daily press have contained statements to the effect that Scientific American is collaborating in an offer of $10,000 to be paid in connection with demonstrations of physical psychic phemomena. Scientific American has no connection with such offer. When our recent investigation of psychic matters ended, as announced in our issue of April 1943, our monetary offer was withdrawn and we now are taking no active part in any matter of this character.

INDUSTRIAL GOLD

Uses May Expand If Price Drops

TODAY'S upheavals may demonetize gold and release more of the metal for industrial and ornamental use. The world's annual gold production is a little over 1000 tons of which 900 to 950 tons are immediately reburied in governmental treasuries, which now hold some 30,000 tons. With government price support withdrawn, the price should fall sharply, and with it production, but the amount then economically usable by industry might be far larger.

Gold is too scarce ever to be cheap; its industrial use must be based on its unusual properties. Although gold is dissolved by aqua regia (a mixture of nitric and hydrochloric acids), it resists all other chemical agents except elementary chlorine and fluorine, by which it is slowly attacked. It is the most malleable and ductile of all substances; one ounce can be beaten into 250 square feet of gold leaf. Particularly important is the fact that it can be fired firmly onto porcelain, glass, and so on to form a fast joint. Another unusual property is ability to weld to itself and to other metals at ordinary temperatures by pressure alone. Finally, gold is one of the easiest metals to heat, cool, or melt, in terms of heat required.

Present industrial uses of gold include gold-platinum alloys for viscose rayon spinnerets; gold-palladium-iridium-platinum alloys in thermocouples designed for extremely accurate temperature measurement; and such therapeutic applications, in addition to dental work, as use of gold-silver alloy plates for repair of skull injuries, permanent insertion of gold capsules containing radioactive substances in malignant neoplasms, and the treatment of arthritis and tuberculosis with gold salts. Electrical equipment for measuring aircraft speeds includes a tiny motor generator with 15-karat gold wire in the generator brushes.

Gold has long been applied to the surfaces of less noble materials by gilding, plating, application of gold leaf, or rolling. The last method consists of soldering or welding a plate of gold onto a block of another metal and then rolling out the covered block to the required thickness, giving a sheet consisting of base metal uniformly faced with gold. An appreciable quantity of gold is used for decoration of pottery, porcelain, and glass in the form of "Liquid Gold," a brownish solution of complex organic gold compounds in essential oils, containing adhesive materials. It is brushed on the ceramic object and, after firing, the pure metal remains as an extremely thin, lustrous surface layer. A recent development in the plating field involves electrically heating gold to its melting point in a high vacuum, the gold falling in a molecular film upon the article placed in the evacuated chamber.—*Industrial Bulletin* of Arthur D Little, Inc.

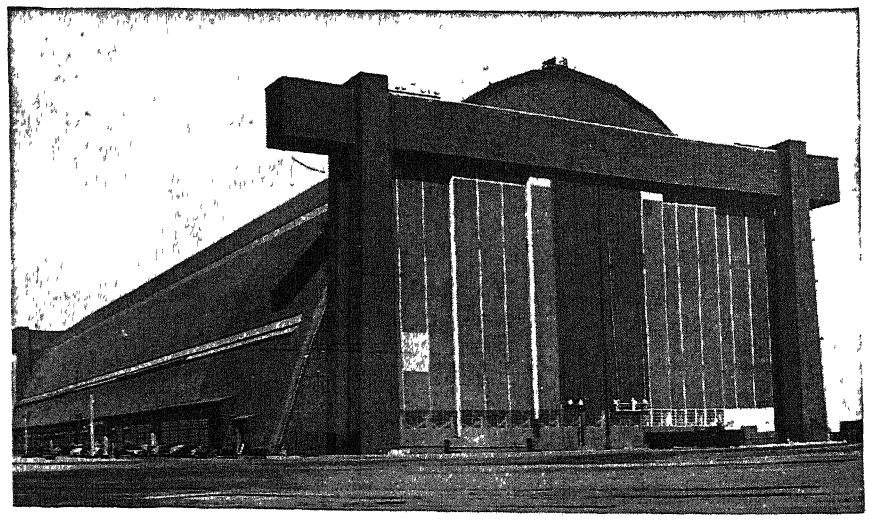
FLAMEPROOFED PLYWOOD

Treated a Carload at a Time by New Process

PLYWOOD'S only serious disadvantage, inflammability, is now being removed by a flameproofing process which gives the material the same fire resistance as the flameproofed timber used in the Navy's new all-wood blimp hangars.

Sheets of plywood are now being flameproofed, a carload at a time, by American Lumber and Treating Company's Minalith process. This pressure treatment employs a combination of phosphate, sulfate, and boron chemicals. Ordinary untreated plywoods burn like untreated timber; with some glues, heat causes delamination of the plies, aggravating the fire hazard. The new treating process, however, prevents flame spread and delamination by filling the wood cells throughout the plies with chemicals which inhibit the flaming characteristics of wood substance.

A procedure followed in flameproofing plywood doors for a West Coast blimp hangar sets a pattern for fire-retardant treatment. The plywood was first fabricated, then impregnated under vacuum pressure in heavy steel cylinders, and thoroughly dried after treatment. The plywood sheets were then given two coats of paint before



Doors of this blimp hangar are made up of flameproofed plywood panels

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Meanwhile, you are invited to attend the demonstration now going on at your local optical establishment franchised by Zenith Let your ears decide—you will not be pressed to buy No salesman will call at your home. Send for our free descriptive booklet The coupon below is for your convenience.

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*

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3 **Special Battery-Saver Circuit.** Insures low battery consumption . makes batteries last up to three times as long.

4 **Zenith Quality, Zenith Guarantee.** Zenith, world's leading manufacturer of radionic products exclusively, is fortunate in having the precision production facilities to supply this quality hearing aid in quantities that make possible its low price Guaranteed for a full year, with unique service insurance plan for life.

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erection, followed by a camouflage paint application after they were set in place.

Plywood sheets are sanded after treatment if they are to be used in natural grain-finish panels. If sheets are to be used in painted units, no sanding is required.

With fire resistance added to its other well known characteristics, plywood may become an outstanding material in post-war construction. Strongest material for its weight, plywood has the stiffness needed in large panels. It need not be drilled for nailing, it has measurable insulating properties, is virtually unaffected by temperature changes, and can be glued as well as fastened by ordinary means.

POTATO PLASTICS

Offer Possibility of Using Agricultural Wastes

FARM WASTES and their potential uses in industry is a subject which has come rapidly to the foreground, forming a basis for considerable research and study. The installation of three white-potato starch plants producing approximately 13 million pounds of starch from cull potatoes annually, and the operation of ten vegetable dehydrating plants in southern Idaho, have together resulted in the production of immense tonnages of waste material, thereby making the consideration of waste disposal a timely topic for chemurgic research.

Anticipating the problem, the Idaho committee of the National Farm Chemurgic Council laid its plans a year ago for research. The disposal of over four million pounds of potato pulp remaining after starch extraction posed the first question to which an answer is being sought. The pulp has some value as a stock feed in both the wet and dry forms, but research men became interested in the possibility of making plastics from it.

Preliminary investigations demonstrated that the residue remaining from the potato starch making operation in its natural form, if properly handled, would plasticize when subjected to heat and pressure The plastic so produced was limited as to flow and water characteristics.

Research chemists at the College of Idaho went to work for the Committee on the problem of improving these characteristics. Their efforts have resulted in a marked improvement in the molding powder and plastic articles which are now produced. Tests show moisture absorption within limits suitable for many commercial uses, and flow characteristics are suitable for the molding of many articles. Shrinkage can be controlled and appears to be within acceptable limits. Metal inserts cast into the plastic remain firmly imbedded and withstand the usual tests for this use.

Belt pulleys of the "V" groove type have been made from the potato pulp, and also with sweet clover fiber added. These pulleys are found to be satisfactory for driving fans, air compressors, and so on. Sample license plates have been made from the potato plastic and submitted to the State of Idaho as a possible substitute for metal license plates.—*Ralph E. Gale, in The Chemurgic Digest.*

PAINT MEASUREMENTS

Made by Two New Testing Machines

THE DEVELOPMENT of two new machines for controlled testing, measurement, and evaluation of the flexibility, scratch hardness, and adhesion of paints and other coatings, was announced recently by The Arco Company, manufacturers of industrial, automotive, and special infra-red camouflage paints.

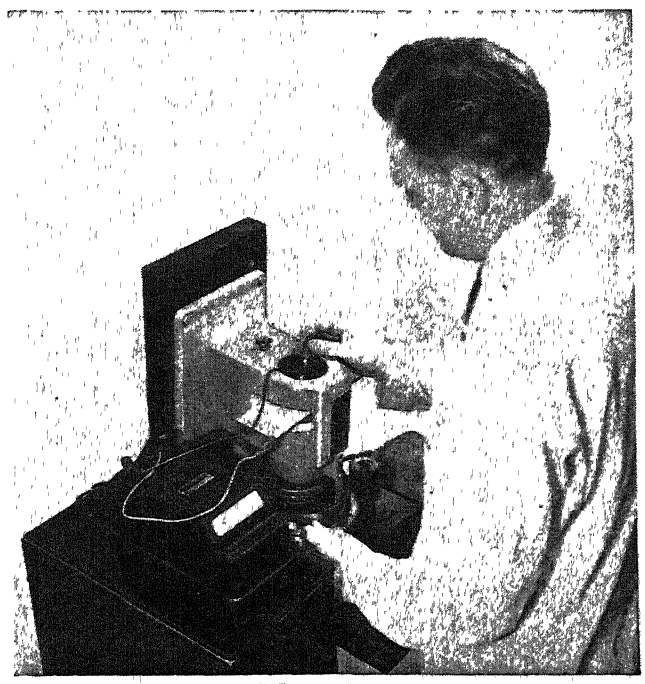
Tests and measurements of flexibility are made on a machine known as the Elongage. This has been developed around a conventional Erichsen sheet-metal testing machine, which was adapted to provide complete automatic controls and accurate measurements for cycle testing. The machine is mounted with its observation well in a vertical position so that water from a hypodermic syringe is in contact with the paint film being tested. Two wires, one of which is attached to the test panel and the other to the hypodermic needle, are connected to a galvonometer.

The machine is operated by a constant-speed drive geared to thrust a 3/16-inch spindle against the back of the test panel which is clamped between two anvils The paint film being tested acts as an insulator. When it fails, the water contacts the steel test panel and a current flows. This deflects the galvonometer meter which signals the end point of the test

The thrust is measured in 1/100mm and is converted to percentage of elongation by a fixed table. In this way the points at which failures occur on identical panels after various degrees of exposure can be accurately measured, recorded, and compared.

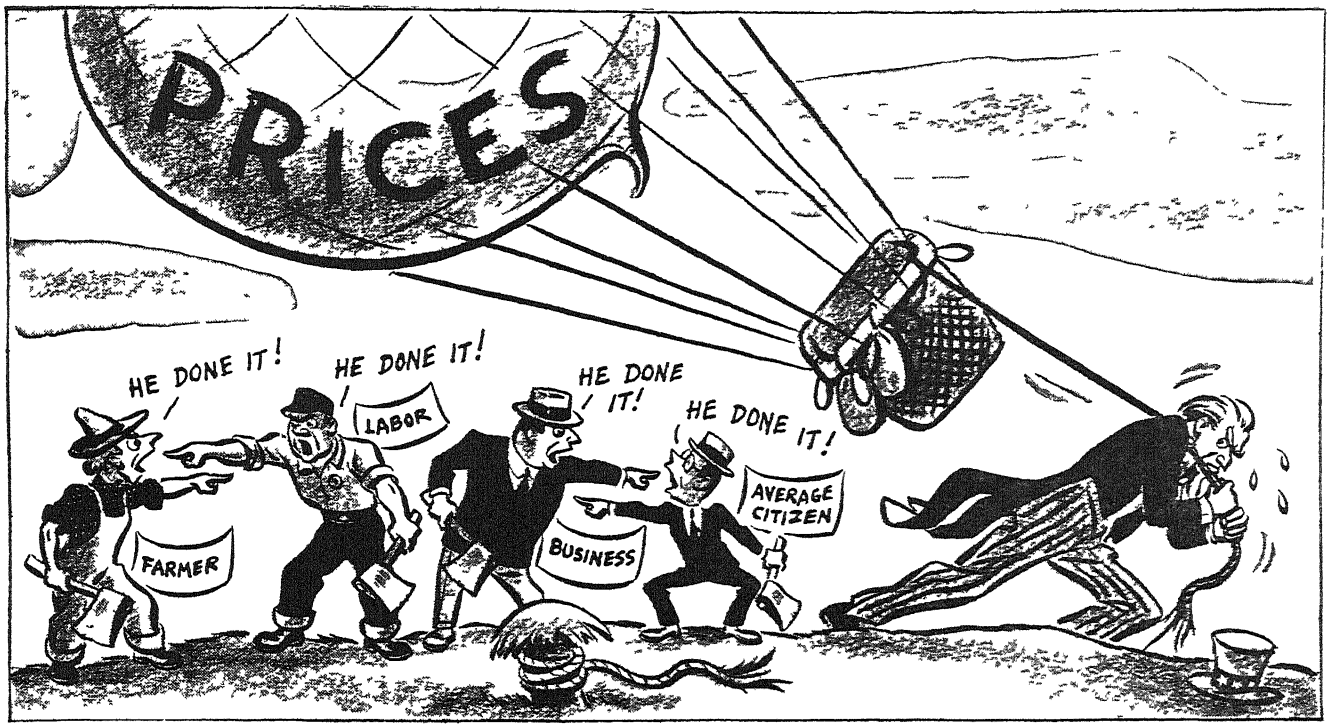
Scratch hardness and adhesion are measured by the Microknife. This consists of a diamond-point cutting tool which is applied to the surface being tested by a lever arrangement carrying beam and weight. The load, measured in grams, is applied to the point, which moves across the surface at a constant speed and cuts repeatedly in a fixed position until the sub-surface is revealed. The load on the beam and the number of strokes required to wear through the film are the measure of scratch hardness. The diamond-point tool is rotated at each stroke to maintain constant sharpness over long periods.

Used in connection with a movable platform which can be adjusted laterally by a precise screw thread and notched wheel, the Microknife becomes an accurate adhesion measuring machine. Tests are accomplished by applying a



Testing paint-film flexibility with the Elongage, described in the text. The panel under test may be seen in the device

Using the Microknife for checking scratch hardness and adhesion of paint films. Note the diamond-point cutting tool



Never mind "who done it"—pitch in and help get it down!

THIS IS YOUR UNCLE SAM talking—but I'm going to talk to you like a DUTCH uncle, to keep all of us from going broke.

Ever since the Axis hauled off and hit us when we weren't looking, prices have been nudging upwards Not rising awfully fast, but RISING

Most folks, having an average share of common sense, know rising prices are BAD for them and BAD for the country. So there's been a lot of finger pointing and hollering for the OTHER FELLOW to do something—QUICK.

The government's been yelled at, too "DOGGONNIT," folks have said, "WHY doesn't the government keep prices down?"

Well, the government's done a lot That's what price ceilings and wage controls are for—to keep prices down. Rationing helps, too.

But let me tell you this—we're *never* going to keep prices down just by leaning on the government and yelling for the OTHER FELLOW to mend his ways

We've ALL got to help—EVERY LAST ONE OF US.

Sit down for a minute and think things over. Why are most people making more money today? It's because of the SAME cussed war that's killing and maiming some of the finest young folks this country ever produced.

So if anyone uses his extra money to buy things he's in no particular need of . . . if he bids against his neighbor for stuff that's hard to get and pushes prices up . . well, sir, he's a WAR PROFITEER That's an ugly name—but there's just no other name for it.

Now, if I know Americans, we're not going to do that kind of thing, once we've got our FACTS straight.

All right, then Here are the seven rules we've got to follow as GOSPEL from now until this war is over Not some of them—ALL of them Not some of us—ALL OF US, farmers, businessmen, laborers, white-collar workers!

Buy only what you need. A patch on your pants is a badge of honor these days

Keep your OWN prices DOWN. Don't ask higher prices—for your own labor, your own services, or goods you sell Resist all pressure to force YOUR prices up!

Never pay a penny more than the ceiling price for ANYTHING Don't buy rationed goods without giving up the right amount of coupons

Pay your taxes willingly, no matter how stiff they get This war's got to be paid for and *taxes are the cheapest way to do it*

Pay off your old debts. Don't make any new ones

Start a savings account and make regular deposits. Buy and keep up life insurance

Buy War Bonds and hold on to them Buy them with dimes and dollars it HURTS like blazes to do without

Start making these sacrifices now—keep them up for the duration—and this country of ours will be sitting pretty after the war . . . *and so will you.*

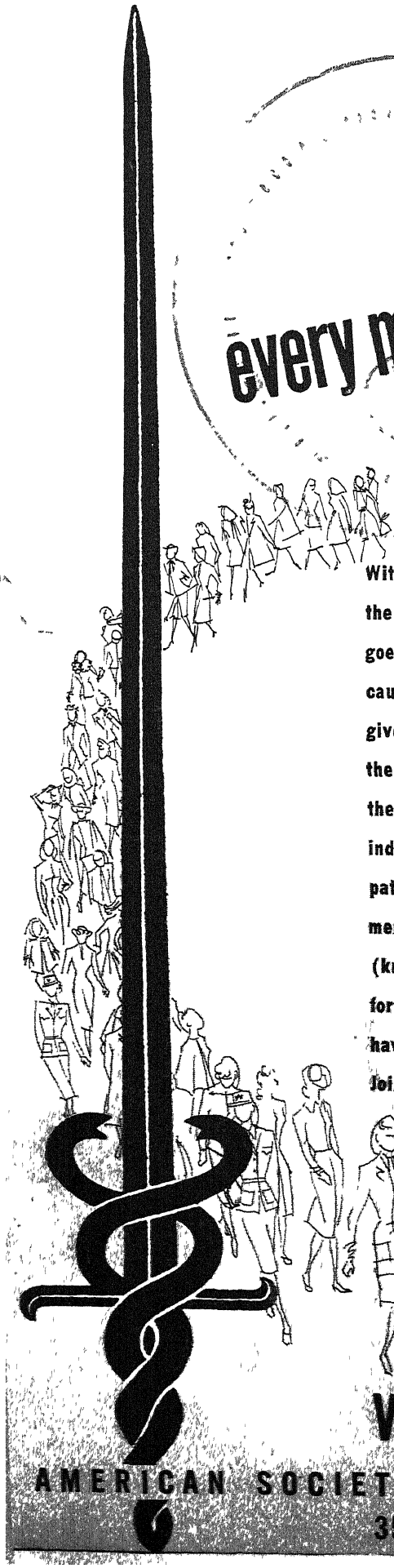
Uncle Sam

KEEP PRICES DOWN!

Use it up • Wear it out
Make it do • Or do without

This advertisement, prepared by the War Advertising Council, is contributed by this magazine in co-operation with the Magazine Publishers of America.

every minute of the working day...



With every tick of the clock, somewhere in the United States, the work of the Women's Field Army of the American Society for the Control of Cancer goes on. These women of the Army against cancer, volunteers in the great cause of cancer control, are spreading throughout the country the knowledge given to them by the medical profession, which helps to guard themselves, their families, and their friends against the scourge. They have taken up the sword, doing a valiant task for cancer control. In many places they are industriously at work, making surgical dressings, and bandages for cancer patients in need, helping indigent patients to obtain diagnosis and treatment. Do you have time to give to this worthy cause? To make bandages, (knowing that these bandages will be a comfort) and to bring help and comfort to some sufferer? If you have, enlist and you will be well rewarded by having the satisfaction of knowing that you are part of a great movement. Join the WOMEN'S FIELD ARMY in your State.

WOMEN'S FIELD ARMY

AMERICAN SOCIETY FOR THE CONTROL OF CANCER

350 MADISON AVENUE • NEW YORK 17, N. Y.

standard stress at progressively smaller spacings until the stress is sufficient to displace the coating in the area between cuts. By this means it is possible to measure the relative adhesion of a given coating to various base metals and sub-coatings, as well as to record changes in adhesion caused by aging of the paint under various conditions.

GAS TURBINES

Feature Simplicity, Still Lacking in Efficiency

THE GAS turbine offers a near-ultimate in operational simplicity. Now rather widely used to convert waste, hot, combustion gases to useful power, the few prime-mover installations suggest it for large-capacity applications, as in driving large electric generators. If it could be adapted to small units, a true revolution in power generation might result

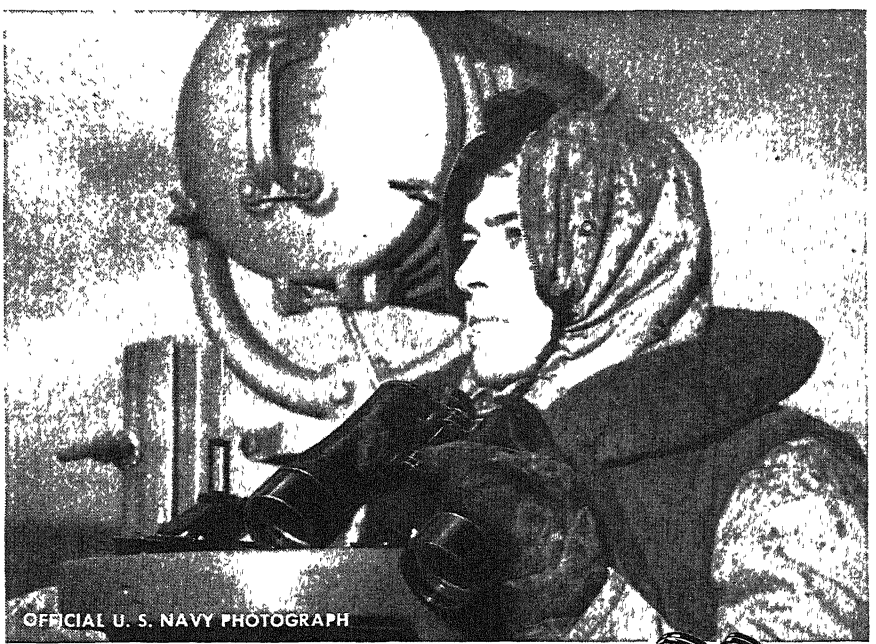
The reciprocating steam engine is a complex, inefficient mechanism requiring an auxiliary steam-generator plant. The more efficient steam turbine reduces the complexity but retains the steam plant, while the gasoline engine and the Diesel, with still greater efficiency, eliminate steam but greatly increase the mechanical complexity. Each of these has found its place, the gasoline engine in light automobiles and aircraft, the Diesel for heavier transportation equipment and stationary power generation, and the steam turbine for the largest units, such as ships and various kinds of central-station electric generators.

Competition continues. The steam locomotive, a reciprocating machine of 8 to 12 percent efficiency, burns the same total weight of fuel as does the automobile in the United States. It is being replaced now by the Diesel-electric, more complex and burning a more expensive fuel, but 20 to 25 percent efficient. The gasoline engine burning 100-octane fuel can achieve efficiencies of about 35 percent, but the extreme complexity of that engine and the high unit cost of the fuel limit it to the various applications where weight saving in engine and fuel load is of the greatest importance.

The efficiency of the gasoline engine would be hard to match, but the gas turbine can outdo it and all other prime movers in simplicity, for it eliminates the steam turbine's steam-producing and condensing system, the gasoline engine's cooling system, and the problem of lubricating hot, sliding surfaces. This turbine is simply a special sort of enclosed multiple windmill driven at high speed by a hot wind produced by burning a fuel in a stream of air. The wind may be produced especially for the purpose or may occur incidentally to another process, as in the use of aircraft engine exhaust gases to run turbo-superchargers (simple gas turbines), which compress thin, high-altitude air for the aircraft engine, or in the recovery of power from the burning of deposited carbon from catalysts used in gasoline production. The "by-product" applications are recent innovations and are contributing much to the development of the gas turbine; however, its future as a primary power generator is yet to be determined.

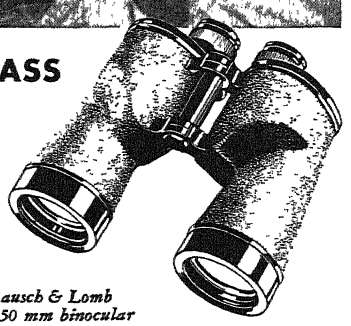
A British patent on a crude gas turbine was issued near the end of the 18th Century. Then, as now, the objective was to eliminate the steam plants, condensers, and so on, and to produce rotary power without the intermediary of cranks, connecting rods, pistons, and so on. And then, as now, the usefulness of the device was limited by its poor adaptation to small units and the difficulty of finding metals to withstand the temperature of the combustion gases. The manufacture of small gas turbines would still require impractically high precision (an insignificant power "leak" of a given size in a large unit becomes of dominant importance in a small unit), but the usefulness of large power units has increased greatly since the 18th Century and metallurgical advances have raised the permissible operating temperature to practical levels.

A Swiss oil-burning gas-turbine locomotive built just before the war with the materials then available was reported to show an overall efficiency of 15 to 18 percent, comparing with 8 to 12 percent for a steam locomotive and about 28 percent for a good stationary steam turbine. In the gas turbine an air compressor attached directly to the turbine shaft forces in the air needed for combustion, and in some models forces in considerable excess air to pre-



BINOCULARS LIKE THIS MUST PASS

a "swimming" test



Bausch & Lomb 7X, 50 mm binocular

Bausch & Lomb developed the first waterproof binocular—a binocular which can be immersed in a tank of water, yet due to its water-tight construction, not a drop of water can get into the interior to fog the optics or interfere with its perfect functioning.

This engineering achievement required a complete redesign of the instrument, complete re-tooling and revised manufacturing procedure. All this was accomplished without interrupting the scheduled even flow of needed binoculars to the armed forces.

Based on this redesign, both the Army and Navy now specify that *all* binoculars supplied to them be of waterproof construction.

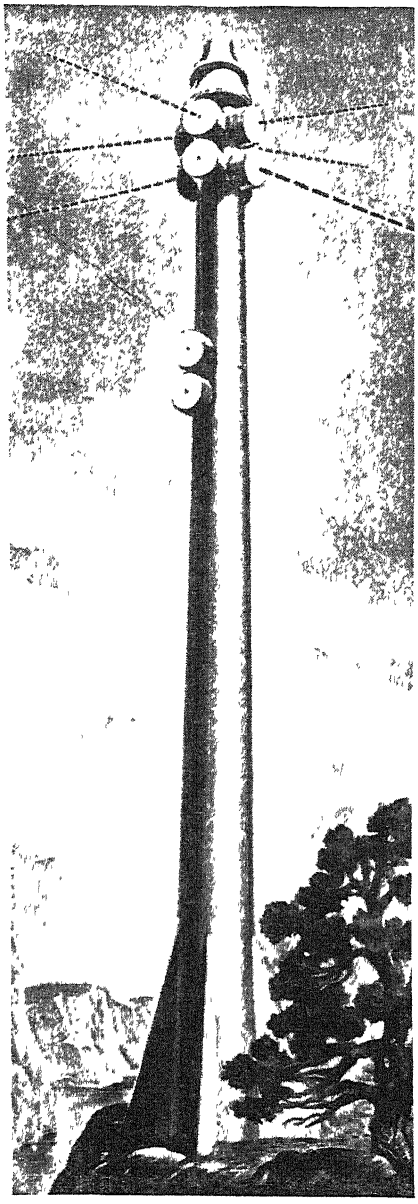
Facilities of this plant — developed through 90 years of service to outdoor enthusiasts, to science and industry—are busy today fighting a war. After Victory new miracles of optical science for better living will come from the drafting tables, the glass furnaces and the precision finishing rooms of Bausch & Lomb, optical headquarters of America.

BAUSCH & LOMB

OPTICAL CO. ROCHESTER, N. Y

ESTABLISHED 1853

AN AMERICAN SCIENTIFIC INSTITUTION PRODUCING OPTICAL GLASS AND INSTRUMENTS FOR MILITARY USE, EDUCATION, RESEARCH, INDUSTRY AND EYESIGHT CORRECTION



Artist's conception of how a television relay station of the future may appear. Signals will be beamed

vent the combustion gases from raising the operating temperature too high. In a recently developed arrangement of two gas turbines, the excess air going through the first is used for combustion in the second, where the inert combustion products of the first keep the temperature down, thus reportedly raising the efficiency to some 23 percent at the same operating temperature.

As with any heat engine, the efficiency of the gas turbine rises markedly as the operating temperature is increased. Thus a turbine efficiency of 18 percent at 1000 degrees, Fahrenheit, rises to 23 at 1200 degrees, Fahrenheit, apparently the top limit of the forged alloy steel rotor blades used in existing gas turbines. Precision casting methods developed for making the rotor blades for airplane turbo-superchargers from new, non-machineable, non-ferrous metals permit a temperature of 1500 degrees, Fahrenheit, and perhaps higher, with a wholly disproportionate gain in efficiency.

The manufacture of a small turbine, say of automobile size, is difficult, but not impossible. In larger sizes, designs for airplane turbine engines have been proposed in Switzerland, although none has been reported used in flight, and present ratios of weight to horsepower seem unfavorable.—*Industrial Bulletin* of Arthur D. Little, Inc.

RADIO RELAYS

Promise Farflung Television Networks After the War

NATION-WIDE television networks made possible by automatic radio relay stations, and other new developments which eventually are expected to lead to finding the key to international television, are a post-war prospect, according to Ralph R Beal, Research Director of RCA Laboratories.

A radically new form of "lighthouse" radio relay station will make relaying of television programs a relatively simple matter, according to Mr. Beal. He envisages that these unattended relay stations, located 20 to 50 miles apart, will not only link television stations into national networks but will open up a new era in international communications, through development of trunk lines over such vast areas as Russia and China.

"It is to be expected," says Mr. Beal, "that television stations will first go on the air in such broadcasting centers as New York, Chicago, and Los Angeles. But there is every indication that alert broadcasters will keep pace with them in such localities as Boston, Philadelphia, Washington, Pittsburgh, Cleveland, Detroit, St. Louis, Kansas City, Omaha, Denver, and San Francisco. It seems logical to assume that the first television network linked by radio relay stations will be formed along the Atlantic Seaboard.

"But television will not be limited to the larger cities. The radio map will be dotted with stations in cities like Schenectady, Utica, Syracuse, Minneapolis, Erie, Buffalo, Louisville, and many others By the use of radio relays, these too will become outlets for the television network which before many years pass after the war, will weave from the east across the Mississippi and the mid-west plains to meet a Pacific Coast link striking eastward across the Rockies. A relay station atop Pike's Peak might well be the key station to complete a transcontinental television chain."

Radio relaying will be a comparatively simple process, Mr. Beal explains. The relay transmitters will operate on microwaves with the energy concentrated almost in a bee line. Practically all the power is made to serve a useful purpose; it is not scattered as in broadcasting. Therefore, relatively small amounts of power will operate the relay transmitters. The apparatus is neither cumbersome nor complicated. It is simple and compact. It could not be otherwise and still perform in the domain of tiny wavelengths which bring radio men so close to the frontiers of light.

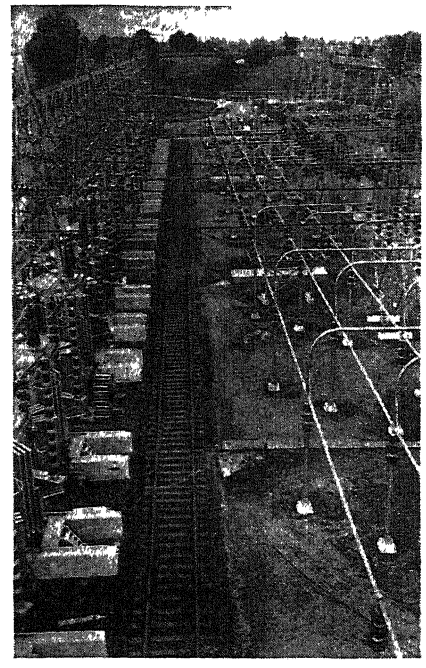
"We know, of course," continues Mr. Beal, "that ultra-short waves travel in a straight line and leave the earth on a tangent at the horizon. The area of the earth's surface touched by such waves is much like that touched by a stick held against a basketball. Obviously, if we use high towers or antennas on lofty buildings or mountain peaks, we capture and re-transmit the waves at higher levels, and therefore their effective range is lengthened. With the use of radio relay stations, the average range is about 30 miles, depending upon the terrain and various other factors. It is interesting to recall that an airplane over Washington, D. C, carrying a television receiver, intercepted the pictures from the NBC aerial on the dome of the Empire State Building 200 miles away. But for such long distance reception of the ultra-short waves, the plane had to go up 20,000 feet."

IRON PIPE BUSES

Find Satisfactory Use in Large Power Plant

ENGINEERS of the Bonneville Power Administration in Washington have put wrought iron to work as a capable substitute for war-scarce copper and aluminum electrical buses. This is reported to be the first recorded instance in which this metal has been used for such current-carrying mains and, according to J. A. Gerber, assistant engineer at Bonneville, "wrought iron need not be classified as an 'ersatz' material; there are many points in favor of using it for permanent buses."

Determination of the ability of wrought iron pipe to serve for these buses is expected to eliminate further need of borrowing for this use from the government's buried horde of silver. The Treasury Department has been releasing silver to replace copper, aluminum, and tin to needy war industries. Already a half-billion dollars worth (700,000,000 ounces) has been distributed under



First recorded installation of welded wrought-iron electrical buses

congressional permission and War Production Board allocation, but must be returned within five years.

The current-carrying capacity of wrought iron pipe is ample for the Bonneville job, the largest size required being four-inch I. P. S standard weight. The capacity may be further increased, if necessary, by slotting the pipe along its length to break the ferrous loop, and by coating the pipe with a dull black paint to increase the heat emissivity.

Wrought iron has a high modulus of elasticity, permitting long spans, particularly with ice and wind loading, thus saving on insulators, fittings, and supports. It has good corrosion-resisting properties, while paint gives additional protection and is easy to apply

Welding is an easy, quick, and economical way of joining the pipe into whatever bus arrangement is desired. All clamp type fittings are eliminated, since welding produces joints that have high electrical efficiency as well as permanence. Since the pipe expands less than copper or aluminum, fewer expansion joints are required.

STEEL WIRE

Replaces Copper in Transmission Lines

ANOTHER development in the replacement of copper for electrical purposes is found in transmission wires which are now being made entirely from steel. While copper is a better conductor of electricity than is steel, it does not have the strength which permits spanning long distances. Poles or other means of support have to be spaced at comparatively short intervals because the weight of the wire itself, together with the added weight of ice or snow accumulations, would cause breakage in long spans.

American Steel and Wire Company engineers pioneered in the partial use of steel in transmission wires, permitting advantage to be taken of steel's superior strength. The first step was to provide one strand of steel twisted with two strands of copper, the former providing strength and the latter conductivity. The next development was to compound two strands of steel with one of copper, resulting in still greater strength. An obvious logical step might have been to produce a combination of one strand of steel and one strand of copper, but it had been found that such a construction was not practicable; when it is exposed to a wind running parallel to the conductor, such two-strand wire develops an oscillating propeller motion which results in early failure. Much experimentation was engaged in before a suitable all-steel wire with relatively high electrical conductivity was developed.

While the new wire is not designed entirely to replace copper transmission lines, definite advantages are afforded in specific applications such as providing a means of transmitting electric power economically to isolated rural areas or industrial installations. The production of the steel wire is carefully controlled throughout all stages of manufacture. Especial care is necessary in selecting raw materials and extremely high control is maintained in making the steel, rolling the rod, and drawing the wire. A heavy coating of zinc is applied for corrosion resistance The result is a quality product with a high tensile strength and fatigue resistance which meets the rigid requirements demanded of it.

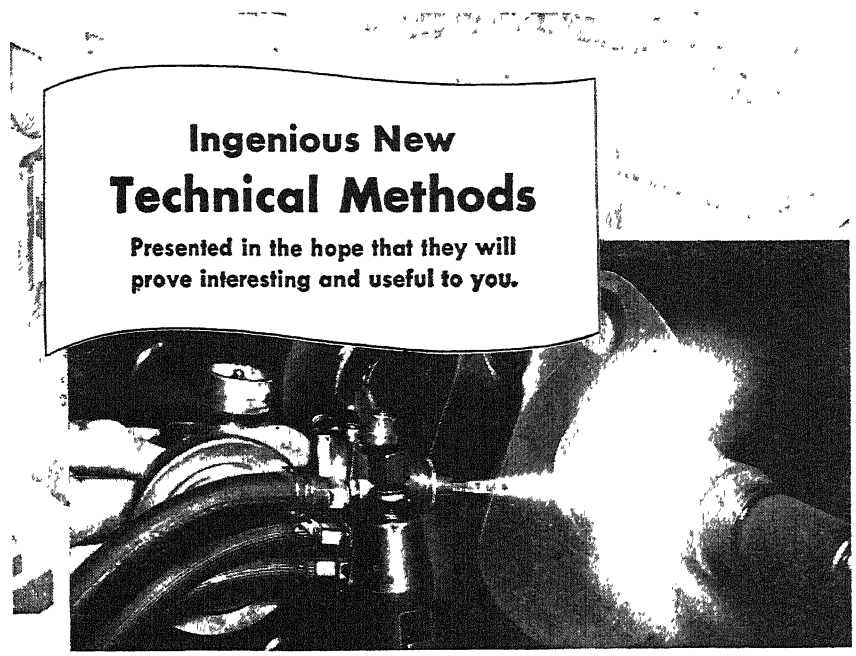
FIRE EXTINGUISHERS

May Display "Emergency" Approval Label

ANY CONFUSION which may arise concerning the distinction between fire extinguishers bearing standard Underwriters' Laboratories approval and those bearing the Laboratories "EAS" approval will be ended by the following explanation.

Standard approved extinguishers bear the usual Underwriters' Laboratories label, which reads "Underwriters' Laboratories Inspected," and gives the serial number of the label and pertinent information on the classification of the extinguisher. That label signifies that the unit conforms to the Laboratories' "pre-war" specifications covering types of materials, details of construction, performance requirements, and so on. Such extinguishers are now available only to very high priority holders.

When war started, restrictions on the use of critical materials made it necessary for the manufacturers of standard extinguishers to develop new models



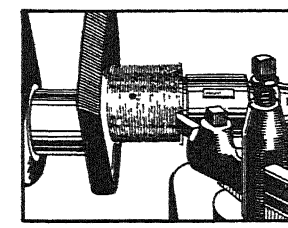
New Metal Surfaces Made by Spraying

Molten metal is now sprayed or atomized on to metal surfaces for the purpose of salvaging worn bearings, shafts, cylinder walls and such parts. Metallizing, as the process is called, is also used for putting a non-corrosive coating on iron or steel surfaces subject to corrosion such as cylinder walls of internal combustion engines, valve gates and such parts in contact with water. The metals to be sprayed may be aluminum, zinc, stainless steel, high carbon steel or other alloys depending upon the character of the surface desired. The sprayed surface may be "over built" and machined down to size to obtain accurate surfaces.

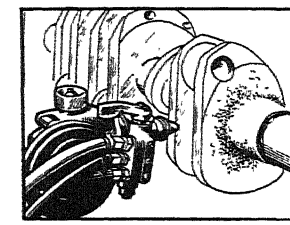
Metal spraying guns have been perfected for use with various types of gases for heat, depending upon the melting temperature of the metal to be sprayed.

We hope this has proved interesting and useful to you, just as Wrigley's Spearmint Gum is proving useful to millions of people working everywhere for Victory.

You can get complete information from The Metallizing Company of America, 1330 W. Congress St., Chicago, Illinois.



Rough threading—cooling locks metal firmly to surface, producing a permanently tight bond.



Sprayed journal before finishing—Main bearing journal after surface has been Metallized.

Y-101

Ultra high-speed motor—a veritable "whirling dervish"—being speed-checked with a stroboscope

using non-critical materials. The solution to this problem was undertaken in co-operation with Underwriters' Laboratories, and a realistic decision was made to sacrifice durability in favor of performance.

Emergency Alternate Specifications were then developed which permit the use of substitute materials, and extinguishers produced under these specifications bear an "EAS" approval label—that is, the Underwriters' Laboratories inspection label has the letters "EAS" added and also the year of manufacture.

Translated into practical terms, this label signifies that the unit on which it appears will perform as well as the standard model, but will require more careful maintenance and cannot be expected to resist corrosion or to stand up as long as the standard type. When standard equipment is once more obtainable, the "EAS" approval will be withdrawn. "EAS" extinguishers now available include pump, tank, and foam types. Many of these are going to priority holders, but some are being released to the general public.

Both labels are intended as indications to insurance inspectors of the degree of protection the equipment affords an occupancy. They serve as comparable indications of reliability to the owner or prospective purchaser of fire-fighting equipment.

"WHIRLING DERVISH"

Grinder Motor Turns at 60,000 Revolutions Per Minute

THE WORLD'S fastest industrial motor—an electrical "whirling dervish" revolving 1000 times a second—has been built by Robert M. Baker, of the Westinghouse Research Laboratories, to drive high-speed grinders that put a mirror-like finish on hard-to-reach internal surfaces of plane and tank engines.

Such grinders are now powered by larger, slower motors connected to the grinding wheel shaft by belts and pulleys. These belts tug at the grinder, sometimes pulling it out of alinement, and they often break because they have to be thin and pliable to bend around the small pulley on the grinder shaft. The new high-speed motor can drive such grinders directly, eliminating production delays for belt replacement and increasing grinding accuracy.

At top speed the rotor of the new motor travels more than 300 miles an hour at its outside edge, less than an inch away from the center of the motor shaft.

"To meet the millionths-of-an-inch tolerance required in finishing aircraft engine parts," Mr. Baker explains "the grinding wheel must cut effortlessly and smoothly, something that can't be accomplished at low speeds.

"Many of these grinding wheels are less than an eighth of an inch in diameter, no bigger than those used by dentists, but they must attain high speeds at their grinding edges. Experience has shown that the best grinding speed is about a mile a minute on the face of the wheel.

"In the future," Mr. Baker continues, "grinders may have to go to ever higher speeds as tolerances grow smaller and smaller. So we are designing another motor that will turn 120,000 times a minute, twice as fast as the one already built."

Although it is only the size of a 1/16-horsepower motor operating on ordinary electric current, the new grinder motor develops 80 times that much power at its top speed. Water flowing through a jacket that surrounds the motor and its bearings keeps the compact power unit cool. The bearings are lubricated by a pump that forces oil through the space between shaft and bearings, a gap less than one two-thousandth of an inch wide.

SEARCHLIGHT

Uses 900-Watt Air-Cooled Mercury Arc

PROVIDING more than 7,500,000 candlepower, a new type of 12-inch high-intensity searchlight makes use of a tiny match-shaped mercury lamp cooled by compressed air. With its 900-watt mercury lamp, this searchlight is four times as powerful as the conventional incandescent searchlight of the same size.

Such heat is created by the mercury arc inside the lamp that cooling air must constantly be forced through a rubber hose into the top of the searchlight drum by an air compressor. Warm air escapes through small ventholes in the bottom. With air cooling, the searchlight can be operated in all types of weather.

New arc searchlight, with back removed

The light beam, pale bluish-green in color, is flat and narrow, making it suitable for many specialized applications such as lighting of distant horizontal surfaces from a low mounting height. Three circular louvers prevent the escape of stray light.

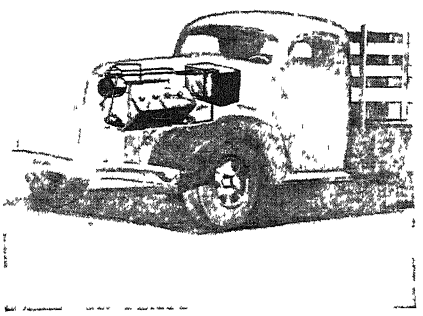
The searchlight is equipped with various safety features which insure among other things sufficient cooling air before the lamp is turned on, and extinguishment of the lamp if the rear door is opened while the current is on.

A 24-inch air-cooled mercury searchlight, using the same tiny lamp and built on the same principles, provides over four times the amount of candlepower supplied by this 12-inch mercury model.

MOTOR WARM-UP

Expedited by Improved Oil-Diluent System

OUT OF the wartime necessity that planes be able to take off within seconds in sub-zero temperatures comes a solution to the problem of starting an automobile or a truck or a tractor on



Oil-diluent system on a truck

bitter-cold mornings. The answer is in the form of a new cold-weather lubrication system for aircraft engines that is adaptable to all types of internal combustion engines.

The system, devised by Leslie T. Miller, Glenn L. Martin Company engineer, consists of a series of basic improvements on the method of diluting lubricating oil with gasoline in order to produce quick starting of aircraft motors in cold weather.

Each engine of an airplane motor has its own reservoir of lubricating oil, holding as much as a hundred gallons. When the motor is running, oil leaves a warm-up compartment within the reservoir, passes along a pipe line into the motor, leaves the motor to pass through an air-cooler, and from there returns to the warm-up compartment.

Under the unimproved method a pilot, after landing in cold weather, presses a button which introduces gasoline into the oil before it enters the motor, and assumes that when he wants to take off some hours later the warm-up compartment, the motor, and all oil

lines will contain a thinned supply of lubricant. What sometimes happens, however, is this:

The diluent, being introduced *before* the oil enters the motor, is partially evaporated out by the hot motor. The result is that completely thinned oil is left only in that part of the line between the point where the diluent is introduced and the motor itself.

When he goes to take off some hours later the pilot may find, while he has perhaps enough thinned oil to start with, the rest of the system is jammed with slugs of thick oil which are likely to burst the air-cooler. An added tragedy is that the plane is usually off the ground by the time the air-cooler bursts, with the result that the oil supply fails, the motors burn out, and the plane crashes.

Even if the damage does not go that far, the old method has the disadvantage of allowing the used oil to return only to the warm-up compartment, with the result that the same oil gets used over and over again, being only gradually replenished by new oil from the reservoir.

The new method, which has proved itself on war fronts where planes must take off within seconds after standing for hours in bitter cold, disposes of these dangers.

In the first place, it introduces the diluent into the oil *after* the oil has passed through the motor. This prevents the hot motor from distilling out the highly volatile diluent, and thus leaves the lines, motor, and warm-up chamber full of thinned oil.

Second, the new method sets up a by-pass which keeps cold and thick oil from getting into the air-cooler and bursting it.

In the third place, the new method permits the use of dual return lines to the oil reservoir—one leading into the warm-up chamber and the other into the reservoir as a whole.

A thermostat located at the point where the diluent enters the oil decides whether the oil shall by-pass the cooler and whether it shall return to the warm-up compartment or to the reservoir as a whole.

Having solved one of the most acute problems of cold-weather flying, Martin engineers believe the automotive industry will adopt, when it gets into production again, this method of starting trucks and tractors and automobiles on bitter-cold mornings.

SUBSTITUTIONS

Make Engineers Resort to Common Substances

MINERAL OIL from the drugstore shelf, common starch from the household laundry, a pigment developed for the paint industry, and many other substances, have been commandeered by RCA chemical engineers to help produce the dependable radio, sound, and electronic equipment for our armed forces.

This war brought to RCA, as to other industries through the country, new and more rigid specifications for completed products, more critical inspection standards, and, almost simultaneously, materials shortages necessitating the use of new and often relatively unknown materials. Resulting problems have been numerous, but the answers have been found in applied science.

Mineral oil was pressed into service by the RCA Chemical Engineering Section when it was found that the wax ordinarily used to impregnate radio coils would flow when too hot and crack or crystallize when too cold, all within the extremes of temperature at which these coils would be required to function. Either failure would expose the wires to moisture, adversely affecting the electrical properties of the coils. This problem was solved by the development of a new impregnating agent, made from mineral oil and cumar resin, which will withstand both extremes of temperature without loss of its protective characteristics.

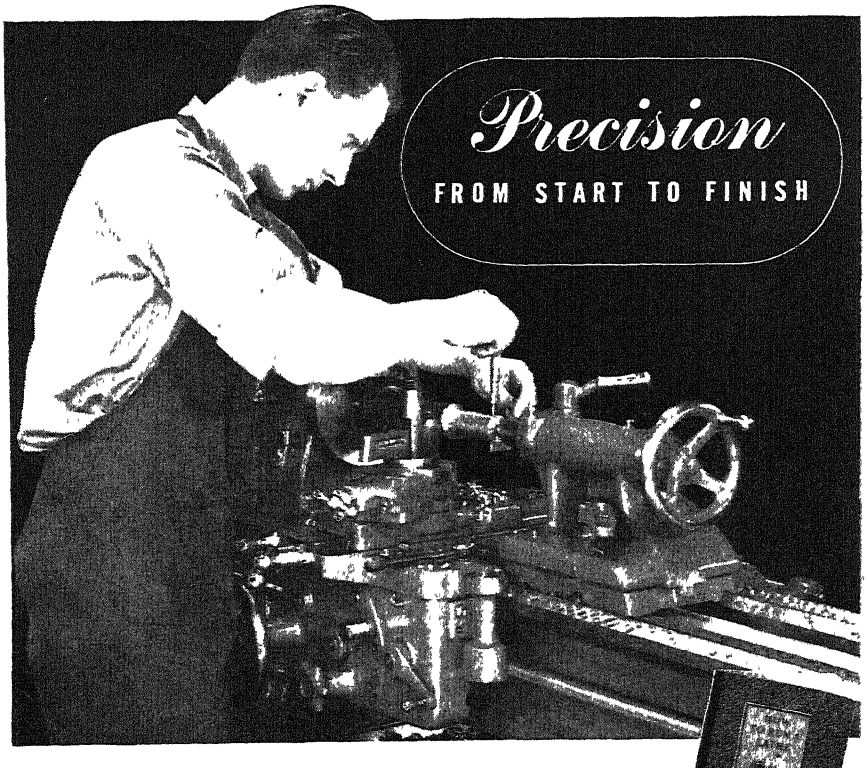
But a tougher problem was posed by the need for a means of soldering aluminum to permit the use of this lightweight metal in products where weight is an important factor, such as chassis for aircraft radio equipment.

Since aluminum cannot be directly soldered in a commercially convenient manner by any known method, a means was sought for plating the aluminum with another metal, to provide an easily solderable surface and, at the same time, a better means of assuring good electrical contact. But neither can aluminum be directly plated, so an indirect approach was necessary.

After some study the chemical engineers found a conducting material which could be applied to aluminum as a film by means other than plating, and developed a process for applying it and for subsequent plating of the aluminum thus treated.

Common starch came to the rescue as a fluxing agent for various soldering operations when it was found that neither rosin nor zinc chloride, which are the agents most extensively used, would do the job in certain applications.

Borrowings from the paint industry involve the use of a black oxide of



War production demands precision from start to finish—from toolroom through production. Without precision, the vast quantities of war supplies so urgently needed could not be produced in time—for efficient mass production is based on a degree of precision which permits perfect interchangeability of thousands of duplicate units.

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iron, specifically developed as a pigment, as the essential material in the manufacture of cores used in controlling the effective permeability of magnetic circuits.

Such satisfactory solutions of materials and process problems as enumerated have been possible because of an extensive background of experience in the various kinds and applications of engineering and science.

SUGAR BEET SEED

Improved Through Use of a Grindstone

BECAUSE science "put its nose to the grindstone," sugar beet growers of the United States saved more than three million man-hours of labor in 1943 and even more significant gains lie ahead.

The saving in labor was made possible by applying mechanical pressure to sugar beet seed, thereby solving a problem which has vexed the industry for generations. The problem arose from the fact that the seed of the sugar beet is not a single cell, but rather a group of cells held together in a cluster. Seed clusters, of course, are not uncommon in nature Beans and corn are familiar examples, and in most cases it is not difficult to separate the individual seeds from the group. Sugar beet seed, however, presents a special problem. The seed cluster is a hard, tight ball, difficult to handle because it is smaller than a pea in size.

When beet seed clusters are planted they may send up a number of sprouts, and since the beet needs "elbow room" to grow and mature, it is necessary to thin the stand so that only single plants remain. Thinning has always required hand work, and there seemed no method of eliminating it unless the seed itself could be changed.

For a number of years plant breeders attempted to develop a strain of beets which would produce single-cell seeds. Some such seeds were grown, but it was never found possible to transmit the characteristics of singleness to succeeding generations, and the experiments were finally abandoned.

Then Professor Roy Bainer of the Department of Agricultural Engineering of the University of California rigged up a device in which a grindstone thrusts the seed against a shearing bar, and under the pressure thus created the cluster splits into single-unit seeds. These single seeds can be planted at regular intervals in the row, and the thinning can be done with a long handled hoe, or with a variety of mechanical tools which require no hand labor whatever. One of these tools is an adaptation of the recently developed cotton chopper, which consists essentially of revolving knives.

The new seed—called sheared or segmented seed—was used extensively for the first time in 1943. It is estimated that the sheared seed reduces the hand labor requirements by at least ten hours an acre, and still greater savings are probable when planting techniques are perfected.

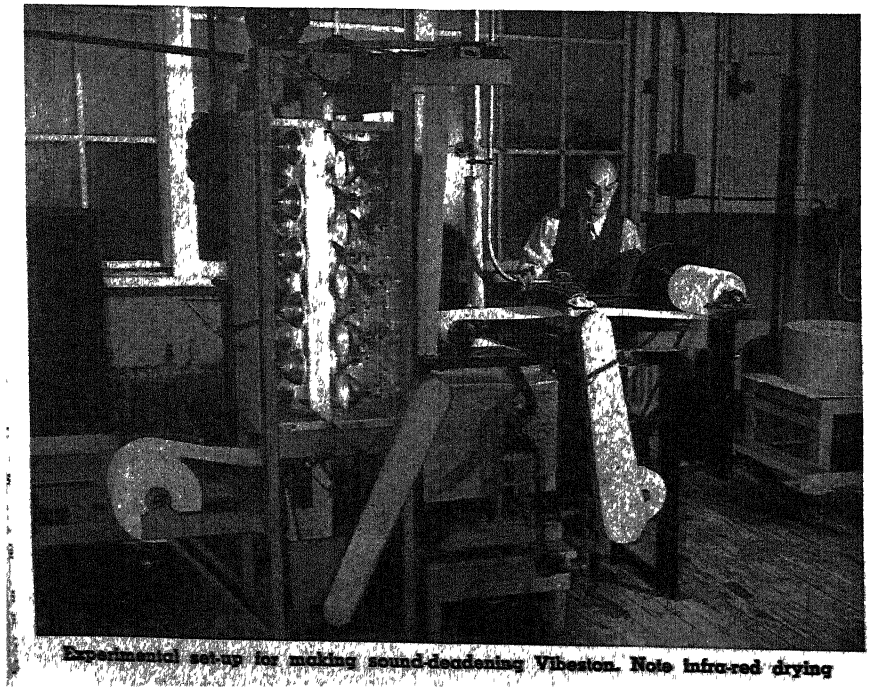
SOUND-DEADENING

Afforded by New Asbestos Composition

A SOUND-DEADENING material which will go far to alleviate a condition that threatens thousands of members of American airplane crews with the possibility of either total or partial deafness is made of asbestos and other nonstrategic materials and is known as Vibeston. It serves both to deaden sound and dampen vibration. The only other known material comparable for this purpose in planes is mica, the major supply of which, from India, was cut off by the war.

Vibeston however, is as much as 50 percent lighter than mica; hence larger areas of planes can be insulated. Moreover, many planes which heretofore had to sacrifice all noise dampeners and vibration deadeners in the interest of lightness can protect the hearing of their crews through the use of the new material.

Mass production of Vibeston is now in progress. Its use will be confined to war purposes for the duration. Its construction is such that after the war it may be used in air-conditioning units and other forms of manufacture where vibration and noise are prime factors.

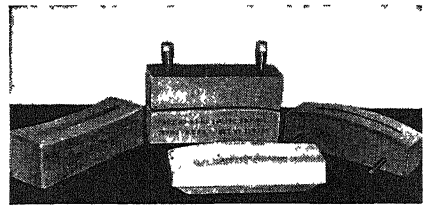


Experimental set-up for making sound-deadening Vibeston. Note infra-red drying

PROTOTYPE DIES

Made Quickly With Low Melting Point Alloy

A NEW production system for making drop-hammer dies for prototype and sample parts embraces the following steps: Construction of a master model or template; production of a plaster pattern of this master model by casting;



Low melting point alloy used in dies. Left: Solid Cerrobend male punch. Right: Female die of same metal. Center foreground: Original plaster model. Center background: A complete die set (punch and die) with drop-hammer mounting

casting dies, embodying the identical contours of the master model, from the plaster pattern.

This process not only produces a die for stamping the parts, but also provides a means of casting checking fixtures for other subsequent operations on the part.

The dies are cast directly from standard size plaster patterns of the part, in a large tank containing circulating cooling liquid. The cooling of a die is accomplished in approximately 45 minutes. The metal used—a standard, low melting point alloy known as Cerrobend—can be pumped through a long, rubber hose to any job that is ready for pouring. As Cerrobend cools it doesn't shrink, which eliminates all problems of machining. Anchor lugs and cores for holding the die in the drop hammer are mounted and cast in place during the pouring.

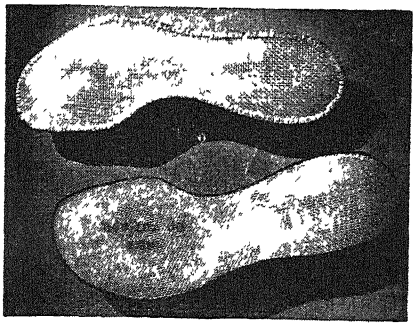
Aluminum, steel, and plastic parts can be made with such dies in quantities of from one to fifty or more, depending on the type of material, thickness, and accuracy required. The system is now in use in plants of the Castaloy Corporation.

INNERSOLES

Made of Plastic, Are Washable, Sanitary

AMONG UNUSUAL wartime uses of modern plastic materials is the Saran screen innersole developed recently by the Quartermaster Corps for use in jungle boots and other military footwear.

The soles, made up of several layers of Saran screen stitched or welded together at the edges, are resilient, flex-



Sanitary innersoles

ible, and tend to ventilate the bottom of the foot. This latter characteristic is expected to aid in the control of fungus foot infections, such as athlete's foot, which are prevalent in humid climates.

Since the Saran plastic absorbs no moisture, the soles may be washed quickly with soap and water, gasoline, or other common cleaning agents and so can readily be kept in a sanitary condition.

The Saran screen used is the same material employed for insect screening in hot, moist climates because the plastic screening is not subject to rusting or corrosion.

CINCHONA TREES

Discovered in Large Quantities in South America

GREAT NUMBERS of wild cinchona trees, needed for quinine and totaquine for war purposes, have been discovered in regions of the other Americas where previously they had not been known to exist in commercial quantities. Specialists from these countries and from the United States Office of Economic Warfare are busy solving transportation and labor problems in these regions, to assure an added supply of the highly strategic cinchona bark, needed for the production of quinine and totaquine to fight malaria. Before the war, the world's main cinchona source was the Netherlands East Indies, to which the trees had been transplanted from South America. Recently returned from a cinchona survey in Guatemala, Colombia, Ecuador, Peru, and Bolivia, Keith Cone, Chief of the Cinchona Section of the Office of Economic Warfare, reported that "there are apparently larger quantities of cinchona than was thought in these countries."

IRON TANNING

Offers Promise to the Leather Industry

OUR SUPPLY of vegetable tanning materials, as well as the chromium used to tan most of the garment and shoe upper leathers for both civilian and military purposes, depends largely upon ships and safe ocean transportation. The importance of developing domestic materials to meet any emergency is illustrated by the fact that only a short time ago the danger of a serious shortage of chromium was such that it was declared a critical material by the War Production Board. Since iron had been shown by previous investigators to offer some promise as a successful tanning agent, and since an abundant domestic supply of this metal exists, an investigation of the use of iron salts for tanning, with special attention to the replacement of chromium salts, was undertaken by Joseph R. Kanagy and Ruth A Kronstadt at the National Bureau of Standards. At the present time the situation with respect to chromium for tanning has been greatly relieved by the utilization of low-grade domestic ores in the manufacture of chromium salts. Nevertheless, the results of the Bureau's work are of interest.

These results, which are reported in the Journal of Research, indicate that ferric sulfate may be satisfactorily used if certain organic acids are added to the tanning solutions to stabilize them. Lactic, citric, gluconic, and hydroxyacetic acids were found suitable for stabilizing the iron tanning solutions at the pH required for successful tanning. Without them the iron precipitates as the hydroxide, a form useless for this purpose.

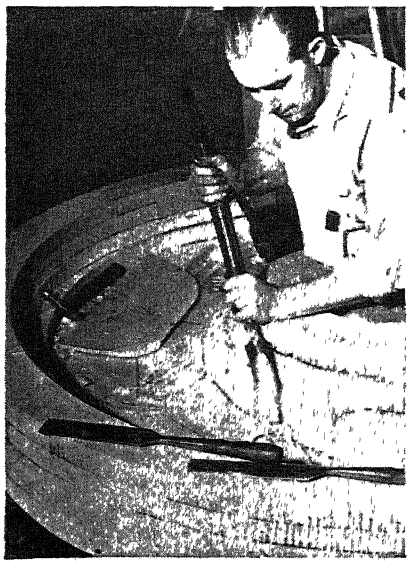
Considerably more iron (Fe_2O_3) than chrome (Cr_2O_3) is required to tan a piece of leather. All hides tanned with the iron contained at least 10 percent of (Fe_2O_3), whereas good leather can be prepared from chromium salts which contain only 5 percent of Cr_2O_3. Experiments with hide powder showed that as much as 25 percent of Fe_2O_3 combined under optimum conditions.

Iron tanning solutions appear to have properties similar to those of chrome tanning solutions. Results of accelerated aging tests on iron-tanned goat and calfskins indicated that, on the average, the iron-tanned leather is slightly less resistant to aging than the chrome-tanned leather.

WOOD CARVING

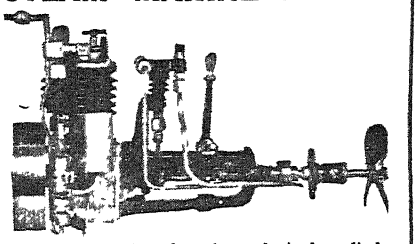
Speeded by Use of Compressed-Air Tools

GUIDED by the skillful hands of the wood carving expert, the modern compressed-air tool is putting pattern making on a new schedule in today's wartime production. According to the Compressed Air Institute, many new and remarkable achievements are being



Carving with a compressed-air tool

STEAM MARINE ENGINE



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DIESEL RING STICKING

Recorded to Indicate

Overhauling Needs

DEVELOPMENT of an instrument which measures and records the blow-by of gases in Diesel engines, thereby indicating whether and when rings are sticking, was announced at the National Fuels and Lubricants Meeting of the Society of Automotive Engineers.

The device, which was said to have accurately recorded sticking rings on every test run so far made and promises to be invaluable in saving time and labor by indicating overhauling needs, was described by R. R. Proctor, A. J. Stock, and D. J. Wangelin, of The Pure Oil Company's Mechanical Laboratory.

The instrument was said continuously and mechanically to record blow-by in cubic feet per minute, revealing the point at which ring-sticking starts and indicating even those temporary periods during which ring gaps are in line or ring flutter occurs.

In testing, the Diesel's crankcase is sealed and all gases are passed through a surge chamber and thence through a standard household gas meter to which a recording unit is attached. Use of a standard gas meter, of a recording unit rebuilt in simple fashion, and even of old recording charts, was said to contribute to economy.

RAYON INSULATION

Being Used on Interior

Telephone Wires

ACETATE rayon yarn is replacing silk for insulating interior telephone system wires and, according to telephone technicians, has proved superior to silk for this purpose, states the American Viscose Corporation. The properties required for telephone central-office wire insulation are stability of electrical characteristics under varying atmospheric conditions, and good aging properties. Experience has shown that acetate rayon surpasses silk in its electrical properties and possesses entirely satisfactory aging properties. The rayon covering is used today in the insulating covering of switchboard wires, switchboard cable wires, and distributing-frame wires.

Metals in Industry

(*Continued from page* 117)

In the new practice the part is heated as usual to above its critical temperature but instead of being quenched in oil at room temperature it is quenched in a liquid bath (a molten salt or lead) at some temperature between 400 and 800 degrees, Fahrenheit, and held in the bath for a given period of time. The steel thus transforms to a new structure known as "bainite" which has properties similar to those of the conventionally treated steel, but which has involved in its production no drastic quench and hence no part distortion.

No subsequent machining to correct distortion is thus required. Furthermore, if the material is heated in a molten salt and then hot-quenched into another molten salt bath, both of which are inert to the steel, it will be neither scaled nor decarburized by the treatment. The part can thus be completely machined in the soft condition prior to hardening, hardened by the hot-quench-in-salt method, and cleaned of adhering salt, and is then ready for inspection and shipping. This new method has been demonstrated by the Roth Manufacturing Company, as applied to the hardening of booster holders and other precision ordnance parts in Ajax-Hultgren electric salt bath furnaces.

BRIGHT GAS QUENCHING

Makes Possible Aircraft Use

Of Welded Steel Tubing

WHEN the aircraft building program was drastically increased at our entrance into the war, *welded* alloy steel tubing began to be widely used for fuselage structures, wing beams, engine mounts, and so on. The aircraft industry had formerly insisted on *seamless* tubing, but the heavy demands could not be filled by this type alone, hence the welded tubes were given their chance and have succeeded with a vengeance

Welded tubing, however, must be made of steel containing a *minimum* of carbon and alloy content, since such ingredients add to the difficulties of welding. On the other hand, the high strength of the tubing is ordinarily obtained by heat treatment, and for this purpose a *maximum* of carbon and alloy content is desirable. Where then, can a tubing material be found that is easily weldable on one hand and highly hardenable on the other?

This dilemma was broken by using the traditional weldable chromium-molybdenum or chromium-molybdenum-nickel tubing steel and applying a special heat treatment that permitted the use of the minimum carbon and alloy content. This heat treatment is more drastic than the conventional "normalizing" (fast cooling in air) and has been called "gas quenching." It consists in passing the heated tubes through a zone filled with a non-oxidizing gas atmosphere that is being blown-in and drawn-out of the zone (that is, recirculated) at a rate more than ten

times that of the "fast" cooling zone ordinarily used for normalizing seamless tubing.

Faster cooling is obtained by "gas quenching" because the protective gas keeps the steel bright and thus increases the rate at which heat can be removed from it, the specific heat of the protective gas makes it an inherently faster cooling medium than air, and the cooling medium is removed at a tremendously higher rate.

The use of bright gas quenching has made it possible to meet Army-Navy specifications for welded aircraft tubing on a large production scale, according to a paper prepared for the American Society for Metals. The tubes can be welded to finished size and no cold drawing is necessary. The new process, developed by William Lehrer, of Surface Combustion Corporation, is typical of the wartime materials-saving, higher-production improvements in heat treating that are here to stay.

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Measuring Roughness

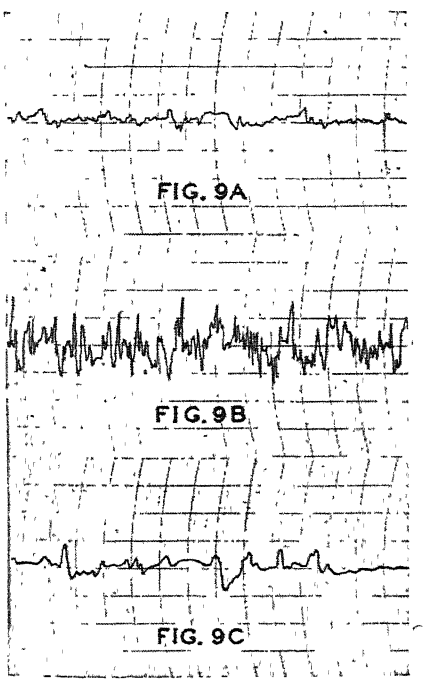
(*Continued from page* 119)

surface so that the area of contact is greater per square inch (the same heat conductivity) decreases the material cost but increases the machining cost. The optimum, of course, lies in between.

In airplane engine design the decrease in weight is of such paramount importance that all of the effort is usually placed on the smallest size and weight of parts. It is a practice in this industry to run engines for 7 to 10 hours under full power output rating and then completely disassemble them. The parts are then carefully examined to see whether any of the bearings were overloaded or were scored due to surface particles breaking loose.

The quick-reading stylus method for measuring finish is also widely used to check each part as it comes off the production line. This is necessary since grinding wheels may go out of round or chatter, the operator may be taking too heavy a cut, and so on. Figure 8 shows a typical production set-up for measuring wrist pins. Each pin is set in the V block and the drive arm slides the diamond stylus and supporting shoe over a small section of the surface. A magnified image is drawn on the graph paper. For a graph of the actual pin under test see Figure 9A. It should be noted that the horizontal and the vertical magnifications are not equal. To make them equal would make the chart clumsy to read. Actually the surfaces are stretched in the vertical direction. Stretching them to their correct proportions would make the true shape appear smooth and gently undulating.

The three traces in Figure 9 have a magnification of 80 on the horizontal axis and a magnification of 4000 in the vertical direction. Therefore, to get a true similarity between the drawn curve and the surface, the horizontal axis must be stretched to 50 times its present length. It can thus be realized that the surfaces measured are relatively smooth. To draw the curves correctly this way would use a great deal of paper. It is for practical reasons then that the horizontal magnification is kept low.



Traces of three different surfaces, made by the Brush Surface Analyzer. Figure 9A is from a fine-ground wrist pin surface, Figure 9B is from an average ground finish, and 9C is from the barrel of a plastic fountain pen. None of these surfaces has these actual contours, all contours being "stretched" 50 times more vertically than horizontally. Each of the finer lines of the cross-section paper represents 1/100,000 inch (ten micro-inches) vertically

Curve 9A is a typical curve for a fine-ground surface such as the one on a wrist pin, shown in Figure 8. The sensitivity of the chart is so set that deviations in the surface of 10 micro-inches will deflect the chart pen one millimeter. It can be seen that this surface has maximum deviations of the order of 30 micro-inches. The average deviations are of the order of 8 micro-inches, or 8/1,000,000 inch.

Curve 9B has the same magnification of the co-ordinates. It is the trace of a ground surface which is obtained from the average grinding wheel—usually specified as "ground finish." The maximum deviations here are of the order of 80 micro-inches with the average running about 25 micro-inches.

Curve 9C is the trace of a well finished barrel of a plastic fountain pen. The non-uniformity of the trace is due to handling of the barrel. The material, being soft, is deformed easily under load.

This brief sketch, surveying the uses of surface measurement, shows that the art is in its early stages of development and that much remains to be investigated. The generation of a good surface is enticing because a delicate touch in the finishing operation may make a tenfold increase in the performance of that surface.

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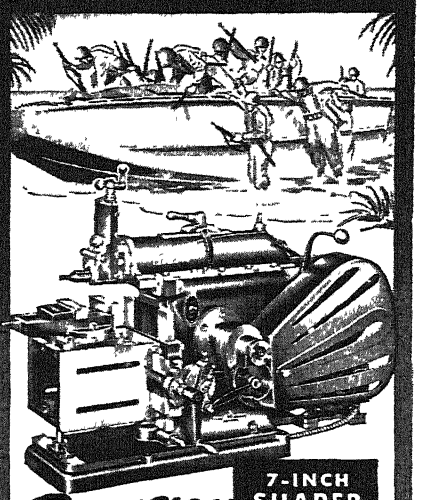

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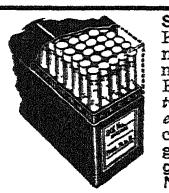

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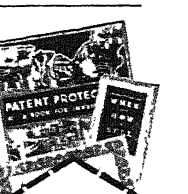

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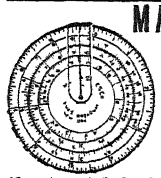

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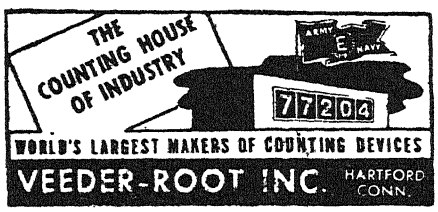

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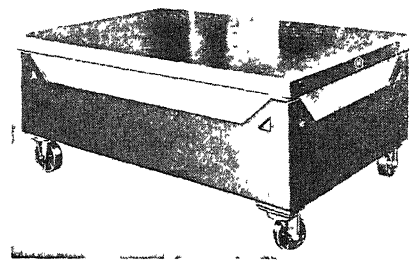
New Products

SURFACE PLATE

DEMONSTRATING that granite is entirely feasible for making even the largest size surface plates, the Herman Stone Company recently turned out a 5000-pound giant which measures four by six feet. Despite its great size and weight, a special steel angle iron wheel



Non-magnetic, glass-like

carriage facilitates ease of handling and makes the plate readily available for service in any part of the plant. Like its smaller counterparts, it presents a smooth, non-magnetic, glass-like surface. This plate may be finished to an accuracy of 3/10,000 inch, while the standard smaller sizes are held to an accuracy of 1/10,000 inch. Being harder than the hardest tools, as well as rust-proof and warp-proof, this huge granite surface plate is practically indestructible.

TEST PLUGS

DEVELOPED for use with the Rotobridge (see page 12, January 1944, Scientific American) in testing electronic equipment, CML production plugs are now available generally for use by electrical manufacturers. These plugs are 5 inches long and 1¼ inches in diameter, made with a heavy steel barrel and fitted with a wooden handle to permit ready removal from socket. All pins are case-hardened steel to assure long life, yet may be replaced when worn or broken. In addition to Octal and Loktal types, these plugs are available in 4, 5, 6, and 7 pin models, small and medium.

DRILL-PRESS FEED

A SIMPLE power feed for drill presses, manufactured by the General Pacific Corporation, and known as the Hydra-Drill, provides a controlled, automatic, fully adjustable power feed for most makes and models of drill presses.

Powered by air, this tool is designed to operate automatically a drill press so that the customary hand feed, while it can be used if necessary for individual operations, is unnecessary for fast production work. The Hydra-Drill permits the operator to devote full time and attention to feeding the work to the drill press. Adjustable stops permit accurate adjustment for all drill-press operations such as drilling, counterboring, spot facing, blind drilling, reaming, and other operations on any type of materials or parts. The range of feed is infinite and can be instantly regulated for fast drilling of soft materials or slow drilling of hard materials.

One particularly valuable feature of the pneumatic feed lies in the fact that the rate of feed of the drill-press spindle can be adjusted so that the pressure of the drill on the work is exactly right for any particular drilling operation, regardless of the size of the drill which is used and the rate of speed at which the drill is operated.

PLATE PUNCH

WITH THE new Wales plate set system for punching holes in flat material, holes may be punched in any pattern in sheets up to 43 inches by 45 inches. The minimum center-to-center hole location is one half inch in any direction.

Each plate set consists of two plates which are made of Walesite, a plastic material uniquely applicable to this new method of hole punching. These are separated by spacer bars, also of Walesite, and are held together rigidly by bolts and dowel pins.

With a master templet, holes are located on top plate of the set. Then larger holes are drilled in top and bottom plates of the set for punch assemblies and dies. Corresponding pattern holes in both plates are drilled in the same operation to assure perfect alinement of punch and die. The entire punch assembly, consisting of punch, stripping spring, guide, and lifter spring, is in-

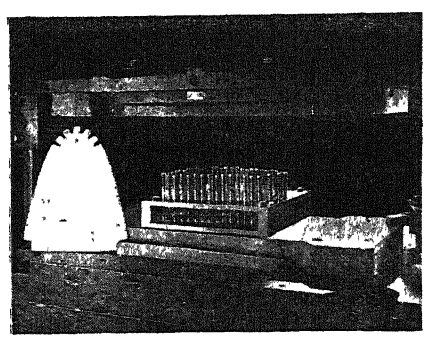
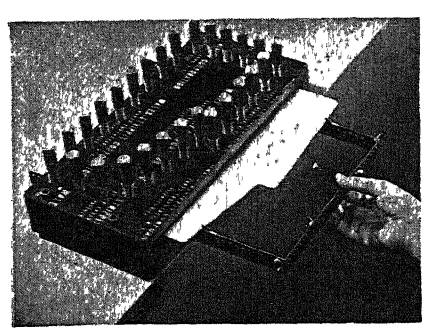


Plate-punch assembly in press



Feed carriage for plate punch

serted in top plate and the die is press fit into the bottom plate.

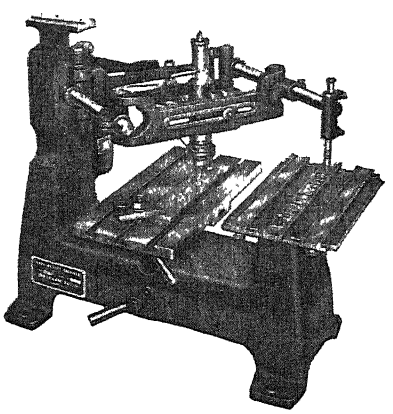
The outstanding advantage of this system is the quick, easy manner in which an entire plate set assembly can be made outside the press. This assembly is ready to operate at the first down stroke of the press ram.

Adjustable feed carriages used with the plate set carry, nest, and remove blanks rapidly and with a high safety factor. Feeding and removing blank with the carriage requires only a flip of the hand.

PANTOGRAPHIC ENGRAVER

ADDING to its line of Panto engraving, marking, and etching machines, H. P. Preis Engraving Machine Company now offers a unit for heavier and more varied engraving work than that performed by its standard Model UE machines. This equipment is said to be suitable for engraving on all metals and plastics, for electrical marking on steel and other ferrous metals, and for acid etching on metals or glass

Designated as the UE-3 Panto Engraver, the machine can be equipped with a forming guide attachment to engrave on concave, convex, spherical, and beveled surfaces. A depth-of-cut regulator is available, to engrave on un-



Versatile engraver

even or curved surfaces. The machine is equipped with endless-belt drive and has four spindle speeds, ranging from 5000 to 12,000 revolutions per minute, making it adaptable for all types of engraving.

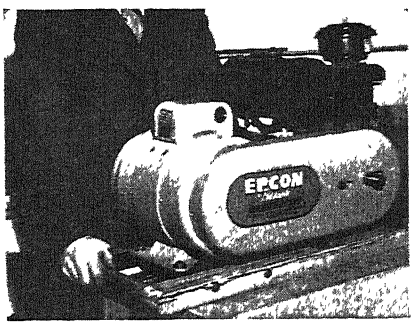
This machine is easily converted from electrical marking to acid etching by replacing the spindle bracket with standard marking or etching units.

PORTABLE GENERATOR

REPORTED to be the most powerful generator of its size ever built, the new air-cooled Epcon B-30 unit, designed to meet wartime needs for portable power and light, delivers 3000 watts at 110-volts A.C., 60 cycle. Net weight is only 305 pounds. Length, including the base, is 34 inches; height 26 inches.

The field ring is annealed cast steel which produces top electrical efficiency for given weight and at the same time gives maximum support and stability to the generator. Cast iron fittings secure both the generator and the Briggs and Stratton engine to oak sled runners which serve as a strong but light base.

End bells, instead of being solid and heavy, are of open design like a wheel with spokes. Dust covers are of light weight steel spinnings The V-belt



Most powerful of its size

drive makes a saving in weight over direct-drive models on which the generator must be heavy and solid enough to be held exactly in the right position for the direct driveshaft

VOLTAGE SELECTOR

A NEW magnetic voltage selector manufactured by Zenith Electric Company, while especially developed for an electro-plating process for anodizing aluminum on A.C., has many other uses where like applications of current are required.

The Zenith selector is for transferring in steps from 2 to 40 volts. The arrangement is such that, when transferring, the main contact opens before the secondary contact opens, and closes after the secondary contact is closed. Arcing is thus effectually eliminated.

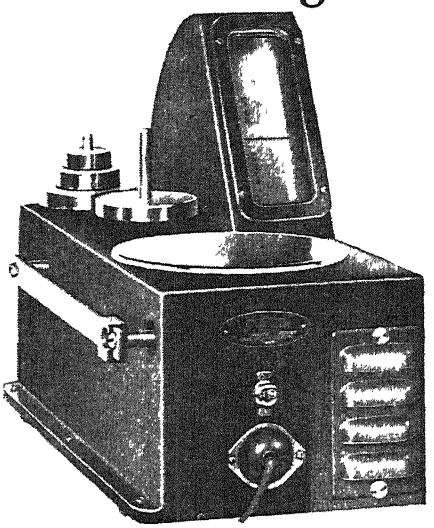
The new unit embodies automatic main magnetic contacts, and automatic main switch contacts for nine positions at 2½-volt intervals.

CARBIDE TOOL GRINDERS

COOLANT control is a feature of a newly designed line of 10- and 14-inch carbide tool grinders. The coolant spouts are fully adjustable, with wide outlets which permit the correct flushing of the work by a slow cascade of coolant, supplied without force. Large splash pans around the table provide adequate protection to the operator, do

Exact Weight Scales

Color Matching . . .



Color matching may depend on weave texture, sheen, surface texture, atmospheric conditions, and a host of other conditions according to the industry. All color matching requires a formulae . . . every formulae must be accurately compounded. Best results are obtained through a simple weighing operation but precision equipment is necessary. That is why EXACT WEIGHT Shadowgraph has been tremendously successful in color blending operations. This is due to high sensitivity with speed of operation with absolute accuracy. Do this — Write us about your operation and correct details will be furnished covering the model shadowgraph best suited to your operation.

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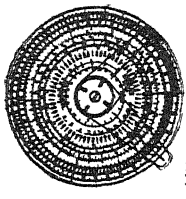

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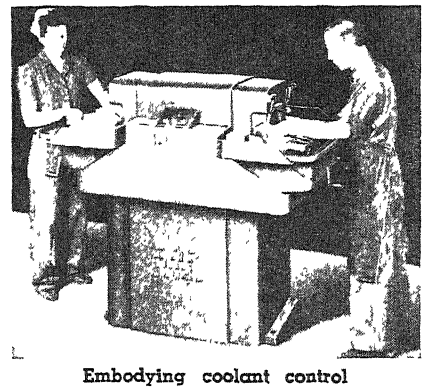


Embodying coolant control

not obstruct vision of the work, enhance operating freedom in movement of tools on the table, and prevent coolant splashing over onto the floor It is said that this new arrangement provides complete control of the coolant while grinding wet, thus operator and floor are kept completely dry.

These machines, just announced by Hammond Machinery Builders, are especially designed for wet or dry grinding of carbide tools.

GOGGLE-CLEANING CABINET

DEVELOPED by Mine Safety Appliances Company to encourage workmen to wear their goggles and keep them clean, a new goggle-cleaning cabinet is equipped with Fogpruf—an efficient lens cleaning and anti-fogging agent—and optical wiping tissues. The unit is designed for mounting in strategic work locations and in repair rooms, tool rooms, locker rooms, or on traveling goggle dispensing carts. Two vials of Fogpruf are concealed within the dispensing block, permitting the cleaning of two pairs of goggles at one time. A tap on either button of the dispenser sprays Fogpruf on the lens. Cleaning tissues are withdrawn from an opening in the top of the dispensing station.

TACHOMETER

A SELF-ENERGIZED Ideal tachometer, recently announced, consists of a small generator coupled electrically to an electric meter. The generator and meter are made as separate elements and coupled together by a bayonet lock. The units may be used together as a "hand type" tachometer or, for many applications including permanent mounting, the generator and meter may be separated and connected only by a two conductor electric cord. A five-foot cord complete with coupling plug is provided, but a cord up to several hundred feet long (of proper size wire) can be used without introducing an appreciable error in scale reading.

Self-energized tachometer

The Ideal tachometer is available in two sizes for 0 to 2500 and 0 to 5000 revolutions per minute.

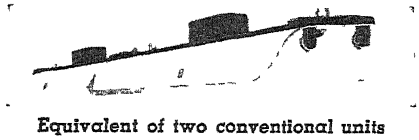
MASKING STICKERS

MASKING stickers, cut to the size and shape specified by manufacturers, have been developed by Avery Adhesives from a material which is easy to handle and which may be applied without moistening and peeled off without scraping or tearing. These pre-cut masking stickers eliminate the necessity of masks being cut by the operator by hand and experience has shown that they greatly increase speed of masking operations, particularly in covering smaller areas.

LUMINAIRE

DESIGNED for easy continuous strip installation, a new light-weight fluorescent luminaire with one-piece, double-length hood and two full-size reflectors is announced by Westinghouse Electric and Manufacturing Company.

Available for use with four or six 40-watt or four 100-watt lamps, the new



Equivalent of two conventional units

luminaire is the equivalent of two conventional units. The hood is fabricated from sheet steel with all ballasts, lamp holders, and starter sockets mounted and wired as part of the channel assembly. Sliding hangers permit suspension from any part of the hood. Mounting arrangements are available for any application. The moisture-resistant, non-metallic reflectors are covered with a multi-coat polymerized finish which provides a reflection factor of 85 percent or more.

AC-DC ELECTRODE

A NEW general-purpose arc welding electrode for welding mild steel in all positions, with either alternating or direct current, named "Fleetweld 37," is the most recent addition to the line of Lincoln electrodes for welding mild and low alloy steels.

"Fleetweld 37" was originally designed as an easy striking, smooth operating electrode primarily for light-gage material. Extensive use in production has also shown it to be a very fast operating electrode under all conditions.

The ability of "Fleetweld 37" to withstand higher currents, both alternating and direct, makes possible higher welding speeds than normal; its easy handling characteristics in all positions make it an ideal electrode for general-purpose work. The fact that with proper currents it will neither stick to the work nor burn through makes the electrode especially desirable for light-gage welding.

Current Bulletin Briefs

Conducted by

K. M. CANAVAN

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

POST-WAR JOBS, by Alfred P. Sloan, Jr., surveys the challenge that confronts American enterprise today and expresses an opinion as to the methods by which the objective should be approached. *General Motors Corporation, 1775 Broadway, New York, New York—Gratis*

THE CORRONIZING PROCESS OF METAL COATING is an eight-page illustrated pamphlet describing the process in some detail, putting forth its varied applications, and listing its advantages. Essentially, Corronizing consists of applying layers of metals and alloys having unusual corrosion-resisting properties. *Standard Steel Spring Company, Corronizing Divison, Coraopolis, Pennsylvania.—Gratis.*

CARE AND REPAIR OF THE HOUSE contains 121 pages of scientifically checked facts on how to keep the house and its equipment in proper condition. *Superintendent of Documents, Government Printing Office, Washington 25, D. C—15 cents in coin.*

HOW ELECTRONIC TUBES WORK is a 24-page non-technical booklet illustrated with 117 sketches and photographs. Designed primarily for industrial engineers, the eight basic types of industrial electronic tubes and their uses are described. Request booklet GEA-4116. *Dept. 6-215, Publicity Divisions, General Electric Company, Schenectady 5, New York.—Gratis.*

STAR CATALOG, No. 43-S, contains a large amount of technical data on metal-sawing operations—both hand and power. *Clemson Brothers, Inc., Middletown, New York.—Gratis.*

"ALLO MAROC," by C. L. Stong, is a 16-page illustrated booklet which dramatically presents the production battle being waged by the communications industry *Western Electric Company, 195 Broadway, New York 7, New York.—Gratis.*

MACWHYTE WIRE ROPE is a 160-page guide for wire rope buyers, 60 pages of which are devoted to helpful information on the conservation and care of wire rope. *Macwhyte Company, Kenosha, Wisconsin.—Gratis. Request catalog G-15 on your business letterhead.*

OIL INDUSTRY AND TRANSPORTATION. . . PRE-WAR AND POST-WAR, by P Harvey Middleton, is a 60-page study outlining the development of the petroleum industry and the services rendered to that industry by various forms of transportation. It endeavors to estimate the post-war demand for petroleum. *Railway Business Association, 38 South Dearborn Street, Chicago 3, Illinois.—50 cents.*

FOUR NEW BUSINESS STUDIES, running from four to twenty-eight pages cover: What Management Can Really Do to Reduce Absenteeism; Representative Cost Systems in the Plastics Industry, Preventing and Correcting Low Power Factor; and Scientific Selection of Office Personnel Increases Production. *George S. May Business Foundation, 111 South Dearborn Street, Chicago 3, Illinois.—Gratis. Request these bulletins on your business letterhead*

REFRIGERATION AND AIR CONDITIONING . . . IN WAR. . . IN PEACE is a lavishly illustrated pamphlet describing the art of manipulating and controlling temperature and humidity in many phases of industry, on the home front, and on the fighting front. *Air Conditioning and Refrigerating Machinery Association, Southern Building, Washington 5, D. C.—Gratis.*

WELDING STAINLESS STEELS is a 64-page illustrated publication covering various types of welding and the effects of heat on different grades of stainless steel. *Allegheny Ludlum Steel Company, Pittsburgh, Pennsylvania.—Gratis.*

INDUSTRIAL SCIENCE LOOKS AHEAD is a 28-page inspirational tabulation of new products and services which the American public may expect in the years to come. The tabulations cover homes, farms, textiles, automobiles, transportation, radio and electronics, and so on. *Department of Information, Radio Corporation of America, RCA Building, New York, New York.—Gratis.*

WARTIME DRIVING TEACHER'S MANUAL is a 184-page booklet designed as a guide for pre-induction and wartime driver education courses It covers: The driver, driver and pedestrian responsibilities, how to drive, and so on. Available through local AAA Motor Clubs or from *The Traffic Engineering and Safety Department, American Automobile Association, Washington 6, D. C.—Gratis.*

THE TOCCO PROCESS is a 32-page illustrated booklet describing in detail this process of induction heating for the treatment of steel parts. Equipment employed and typical applications are shown and described. *Tocco Division of The Ohio Crankshaft Company, Cleveland 1, Ohio.—Gratis.*

ELECTROMODE INDUSTRIAL UNIT HEATERS, bulletin No. 65, describes the construction, operation, and application of heaters suited for heating isolated buildings, offices, or other spaces where intermittent yet high efficiency operation is required. The heaters are available in either portable or suspension models. *American Foundry Equipment Company, 555 South Byrkit Street, Mishawaka, Indiana.—Gratis.*

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Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

IN THIS department in July and August, 1942, data for building a concave grating spectrograph of the Rowland circle type were given by R. M. Watrous. Another form of that type now has been described by Wm. S. von Arx in the *Journal of Chemical Education* (Easton, Pa.) Vol. 19, pages 407-10. As it is the policy of this department to make available to its readers, by reprinting, matter which relatively few of them would otherwise see, the following is extracted from the longer paper. Von Arx, an amateur telescope maker and author of the chapter on Stellar Photography in "A.T.M.A.," originally contributed it to the professional journal named, not in that capacity but in his capacity as a majoring student in science at Brown University. He also drew the sketches. The extract:

There is a new design of grating spectrograph manufactured by Adam Hilger Ltd., of London, under the name "Technal." It has exceptional properties of ruggedness and simple design which are so inherent as to be preserved even when homemade. It is possible to build a modest version of the "Technal" spectrograph in about two weeks of evenings. In no case should the cost exceed $50. Half this amount should be adequate.

First, let it be made clear why the concave grating is preferable to the more familiar prism as a dispersing medium. Prisms introduce irrational dispersion—non-uniform separation of equal wavelength intervals in different spectral ranges—which makes the interpretation of spectrograms unnecessarily difficult for the beginner. Furthermore, the prismatic instrument must always contain three component parts —the collimator, prism, and camera, each of which involves at least one pair of optical surfaces. For analysis in the ultra-violet range, these parts must be made of quartz, which is very expensive. The grating spectrograph, on the other hand, not only produces linear dispersion but may contain no lenses whatever and only one spherical reflecting surface if the concave grating is employed. With these, an aluminized reflecting surface is all that is required for efficient operation in the ultra-violet. This simplicity carries a twofold advantage; it reduces the initial cost of the instrument and makes it easier to keep in adjustment. Another advantage in the use of grating dispersion is the wide range of dispersions available in the higher orders of spectra. While the intensity of these higher orders is usually considerably less than that of the first order, the high intensity of the carbon arc, which is almost invariably used for qualitative analysis of non-conducting samples, allows them to be used for more precise analysis of the complex spectra characteristic of the transition group of elements. The concave grating does possess a few disadvantages, the worst of these being astigmatism. But this can be effectively controlled either by means of properly designed slit illumination systems, or by employing the minimum astigmatism mountings, of which the "Technal" is an example. These reduce the stigmatic error to such a small figure that it becomes unimportant in the normal working ranges.

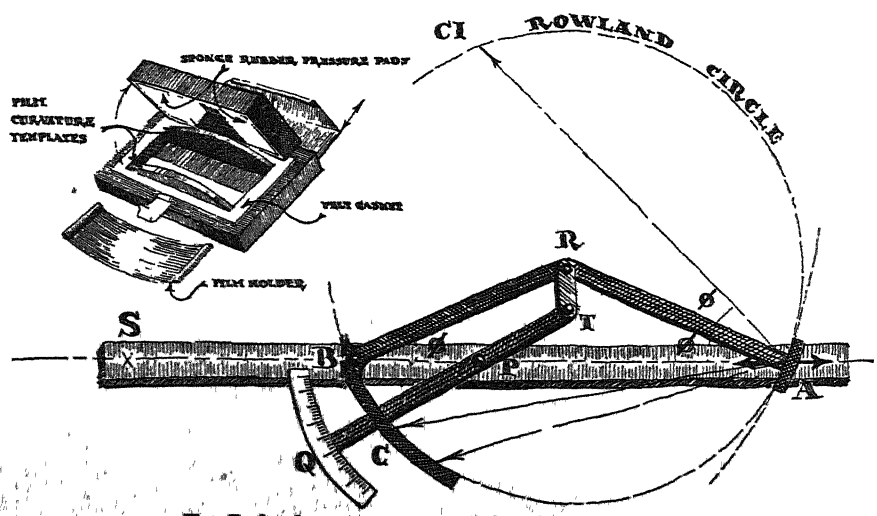
The "Technal" design has no inventor's name associated with it as yet, but J. S. Dowell, of Adam Hilger, Ltd., has described the mounting and the Hilger interpretation of its design, which he credits to Cotton and Richards.

The mechanism involves only three levers of fixed length, a pivoting hinge, and a short track along which the grating moves under control of the lever system. The arrangement of parts is shown diagrammatically in the main sketch, the grating being at *A*, the slit at *B*, and the plate at *C*. The line *BA* represents the center line of the spectrograph bed and the levers *BR* and *AR* are in length one half the radius of curvature of the grating and have the grating and slit-plate elements rigidly fixed to their ends. Where they meet at *R* they are pinned together so as to articulate. A track which is parallel to the bed *BA* is placed under *A*, and is long enough to allow the grating element on the radius arm *AR* to travel along the bed *BA* in the direction of the double-ended arrow for a few inches.

It is evident, since *BR* and *AR* are radii of the Rowland circle of the grating, that by moving the joint *R* toward or away from the line of the bed *AB*, the range of wavelengths recorded on the plate *C* will change. Furthermore, the parts will always remain on the circumference of the Rowland circle and will therefore be in correct focal relation to each other at all times. If a light source is located at *S* on the line of the bed *AB* prolonged, the incoming light-ray must always fall fully upon the grating at *A* no matter what wavelength range is being photographed. If *R* is moved away from the bed it will be found that the plate will record the longer wavelengths or higher orders of dispersion of the grating since the central image *CI* of the slit is on the opposite side of the radius arm *AR* at an angle 2Φ with the bed. The angles Φ are all equal, as is evident from the geometry of the mechanism. They usually have values ranging from 0 to perhaps 10 or 12 degrees.

The angles Φ are varied by moving the joint *R* from outside the instrument by means of the lever *QPT*, which is pivoted on the bed of the instrument at *P* and connected with the joint *R* by a short toggle *RT*. The pivot is somewhat nearer *T* than *Q* in order to provide a small mechanical advantage and greater precision of motion of *R*. The outer end *Q* of the lever sweeps a scale upon which the wavelength ranges for each setting are marked. Not more than half a dozen standard settings need be marked upon the scale. They may be determined by experiment. It is evident that, once adjusted, the entire optical system is completely controlled by the motion of the lever *QPT* and with complete assurance that all optical parts are properly oriented with respect to each other for perfect focus.

All images formed by a concave spherical surface suffer astigmatic distortion except that one image which falls exactly in line with the light source. Astigmatism increases slowly at first as one travels from this point in any direction in the focal plane, but increases rapidly beyond angular departures which are in excess of a very few degrees. Those lines nearest the slit will



The Technal spectroscope and, (inset) its plate holder

be most nearly stigmatic and those farther away will show increasing distortion. It is for this reason that the slit in the "Technal" mounting is placed as close to the ultra-violet end of the plate as possible Since the far ultra-violet sensitivity of plates is always somewhat lower than that of the near ultra-violet and visible blue it is desirable that no light should be wasted in that region. Ideally, the slit should be placed in the very center of the plate, but this is difficult mechanically and would cause great inconvenience in operation.

For spectrochemical analyses of compounds containing iron or other elements of the transition group which have exceedingly complex spectra, two minimum specifications must be observed regarding the dimensions of the optical system of the spectrograph. (1) dispersion of at least 16 angstroms per mm and (2) sufficient resolving power to separate completely two lines of equal intensity not more than 0 4 angstroms apart. In grating instruments this requires a focal length of about one meter, 15,000 lines to the inch, and a ruled surface at least 30 mm wide. The Central Scientific Company of Chicago sells a Wallace replica grating having these minimum specifications for a little more than ten dollars. These gratings are of fairly good quality initially but may be improved by changing the shape of the factory-made mask to be somewhat longer, thereby exposing more ruled surface and increasing the resolving power, and somewhat narrower, in order to compensate for the irregularities in the collodion replica. The precise shape of the mask must be determined by experiment. It is a long and exasperating job but eminently rewarding in the end.

The slit and the plate holder (inset sketch) are the most difficult parts of the instrument to construct and should be given double their share of careful planning and workmanship. A fixed slit of moderately narrow width is recommended. The plate must be curved to the circumference of a circle whose radius is one half the radius of curvature of the grating—the Rowland circle. The "plates" may be strips of 35mm motion picture film if it is expected that only one or two samples will be run at a time; or 8 x 10-inch cut film sliced down the middle to the standard spectrographic size 4 x 10 if more extensive work is anticipated. On these 4 x 10-inch plates it is possible to record at least 16 well-separated spectra with their iron comparisons. The spectra need not be more than three millimeters high if no comparison spectra are juxtaposed, but should be half again as high with comparison spectra, so that about one millimeter of the end of each line can interfinger with the comparison lines. This simple device increases the accuracy of plate measurement, since lines of nearly the same wavelength are more easily classified as coincident or separate.

The astigmatism of gratings causes the ends of the spectral lines to be ragged in appearance, the brightest line being longest. In order to conserve plate space and trim up the spectra, it is necessary to build an extra slit just in front of the plate in its holder. This slit is at right angles to the principal slit of the instrument and is preferably constructed to have variable width. The slit's function is simply to limit the height of the lines and make their outer terminations sharp. A pair of brass-edged foot rulers is admirable for the purpose. They may be made adjustable by coupling the two at their ends in the manner of the navigator's parallel rule.

The light-tight housing around the optical parts of the instrument may be made of sheet metal or of ply-wood screwed to a light wooden frame. The housing should have a door or hatch in it near the grating end of the case so that the grating is accessible for adjustment whenever necessary. A simple flap shutter placed in front of the slit is a convenient accessory. The plate-holder motion scale will be found to be more useful if it is graduated in metric units. The metric scale of a 6" celluloid pocket ruler glued to the plate-holder track with cellulose acetate cement serves admirably.

The design of the bellows between the light-tight housing and the articulating plate-holder track presents something of a problem. Spectrograph bellows are usually of such an odd size and shape that they must be specially made. Bellows cloth costs about one dollar per yard. Bellows may be installed in the usual accordion pleat fashion built up of two layers of bellows cloth with cardboard stiffening pieces cemented between—rubber cement is recommended—or, since the span is always very short, simply cut to fit the gap and allowed to fold as it will without reinforcement inside. The latter is quite satisfactory for small instruments, the natural stiffness of the cloth itself being sufficient.

When the inner mechanism of the instrument is complete, the entire inside of the case and the parts enclosed should be painted dead black. Ordinary blackboard paint is admirably suited to this job, containing enough varnish to stick equally well to metal and wood. Since the instrument is likely to be used in a dimly lighted room, the outside of the instrument is best painted a light gray so that it is more easily seen. It is convenient to mark the rulings on the plate-holder motion scale with zinc silicate paint to which a trace of a uranium salt has been added. A dot of the same on the plate holder makes it far easier to set the plate holder without turning on bright lights in the room. Should the phosphorescent paint be too dim for ready visibility to those coming in from brighter quarters, a small argon night light may be used to excite the fluorescence temporarily.

END OF extract from von Arx's article. While this presents the main data, readers who undertake the actual job probably should obtain the full paper, which is a little longer and which also describes an accessory called the Hartmann diagram for use in photographing two spectra side by side without moving the spectrograph between exposures.

Von Arx is now at Yale University.

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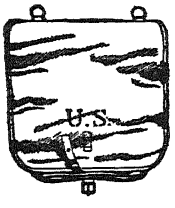

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COVER: Electronic tubes aid in making electronic tubes. The welding equipment shown on our cover, by courtesy of Westinghouse, is being used for seam welding the metal jackets on ignitrons, electronic tubes that convert alternating into direct current Ignitrons are also used in the equipment itself An over-all discussion of electronic control in welding processes will be found on page 157

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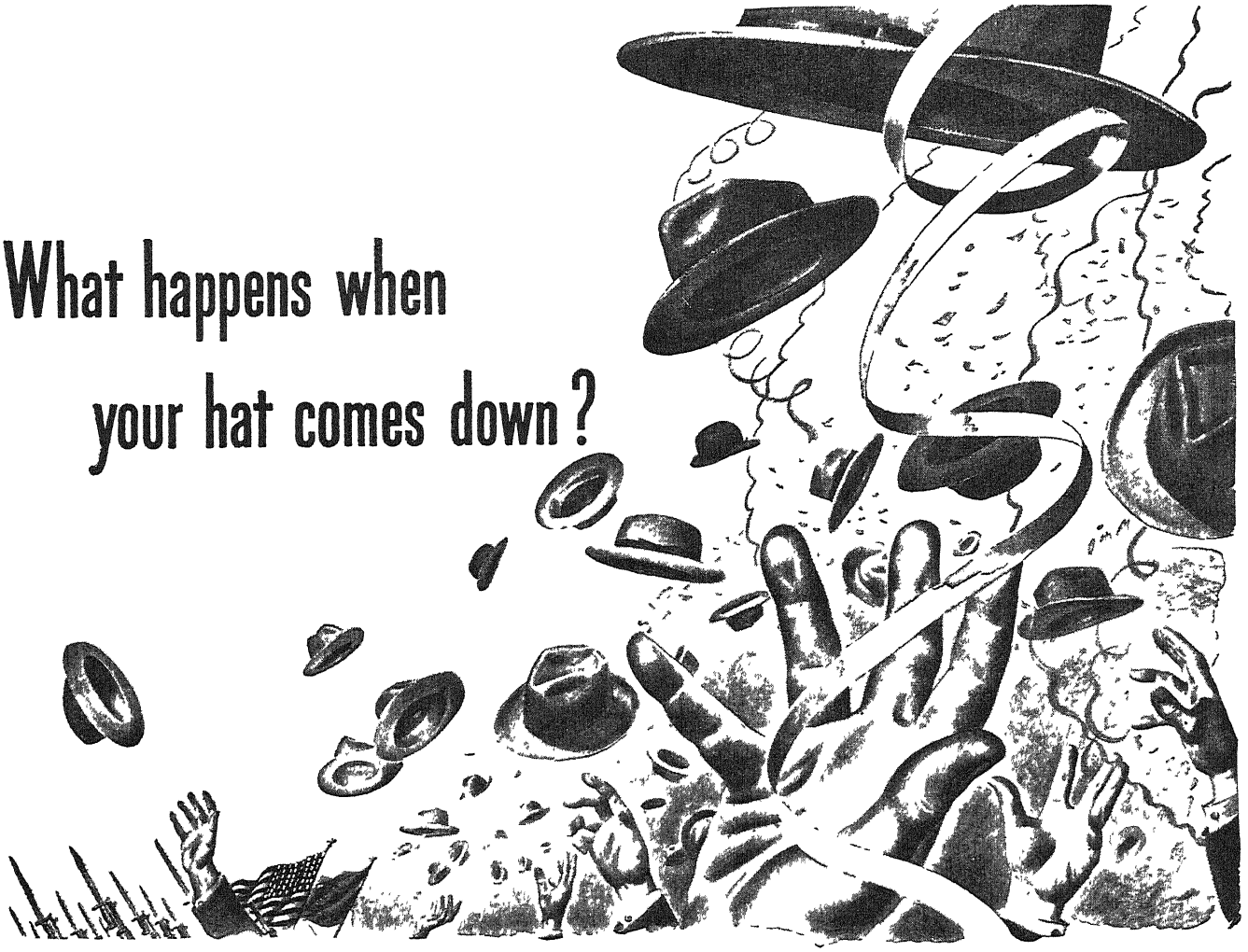
DAYTON, OHIO

What happens when your hat comes down?



SOMEDAY, a group of grim-faced men will walk stiffly into a room, sit down at a table, sign a piece of paper—and the War will be over.

That'll be quite a day. It doesn't take much imagination to picture the way the hats will be tossed into the air all over America on *that* day.

But what about the day after?

What happens when the tumult and the shouting have died, and all of us turn back to the job of actually making this country the wonderful place we've dreamed it would be?

What happens to *you* "after the War?"

No man knows just what's going to happen then. But we know one thing that must *not* happen:

We must *not* have a postwar America fumbling to restore an out-of-gear economy, staggering under a burden of idle factories and idle men, wracked with internal dissension and stricken with poverty and want.

We must *not* have breadlines and vacant farms and jobless, tired men in Army overcoats tramping city streets.

That is why we must buy War Bonds—now.

For every time you buy a Bond, you not only help finance the War. You help to build up a vast reserve of postwar buying power. Buying power that can mean millions of postwar jobs making billions of dollars' worth of postwar goods and a healthy, prosperous, strong America in which there'll be a richer, happier living for every one of us.

To protect your Country, your family, and your job *after* the War—*buy War Bonds now!*

Let's all KEEP BACKING THE ATTACK!

The Treasury Department acknowledges with appreciation the publication of this message by

SCIENTIFIC AMERICAN

Previews of the Industrial Horizon

By A. P. Peck

PLANS AND PLANS

WHO was kidding whom, when broadcasters and broadcasting stations were recently requested to refrain from mentioning post-war planning on the radio? Stated reason was to avoid building up that old boogie of complacency. But since when does planning for the future make one satisfied with the present? Certainly no thinking person—the type in whom rests the future of the world—neglects the present just because he is planning his next steps It seems to us that lack of planning, rather than planning itself, leads to a mental stage of stultification.

If the naughty words "post-war planning" are to be kept under wraps, if the people of this nation are to be kept in the dark about the future, if the problems of post-war employment are to be ignored until post-war, it all leads up to something like this: OK, let's not make plans To hell with it Let's have another depression—the biggest yet.

PRACTICAL PHYSICISTS

DWELLING on the thought that physical science, through pure and applied research, can provide a tonic for the ill of unemployment in the post-war world, Dr. Albert W Hull, well-known research man, recently made a pertinent statement which we can do no better than quote· "This tonic is new products. New products are resistant to depression psychology, and experience has shown that they can be sold when old products can't. In this way, physicists can contribute to the all-important job situation"

This makes sense. Should this type of thinking be suppressed in order to avoid "complacency"?

FIBERS TO THE FORE

BRIGHT indeed is one part of the horizon for textile users —and that means everyone who wears clothes. Fibers from which textiles are made may be divided into natural and synthetic Within each of these groups and between individual fibers of both groups there is growing a competitive situation that is bound to be healthy, even though some will assume secondary positions if they do not fall by the wayside entirely.

Cotton and wool, despite the fact that they account for some 90 percent of all textiles, are the two fibers to which the least research has been applied On the other hand, consider the case of rayon This fiber, first developed many years ago, has been constantly improved and now stands in a position to challenge many markets formerly closed to it.

In recent years, also, laboratories have put forth a number of synthetic fibers, stemming from such diversified sources as milk, soybeans (more about this next month), wood, chemical combinations, and so on. All of these have received intensive study during the war The outcome is going to be better textiles for everyone, in greater variety than ever Which textile fiber or fibers will lead the field will largely depend upon the extent to which science is drawn into the picture by those with the greatest stake in the future

STANDARDS

THE ACCEPTED connotation of the word "standards" in industry includes accurately defined processes, sizes, qualities, and tests of materials and equipment that have been generally agreed upon by makers, users, and the public as proper and desirable for general use. Upon the basis of standards has been built the whole scheme of mass production. Standards here are generally dimensional, insuring interchangeability of parts. In other phases of production, also, standards have been proved not only worth while but usually invaluable.

Before World War I the desirability of standards in many industries became apparent. Since then they have been evolving to a point where, during World War II, they have come to a high point of perfection But still this is not enough. When free competition replaces our war economy—and this is the only sane basis for thinking—there will be even more room and need for industrial standards. The many new materials and processes developed during the past few years will need standardization if they are to be applied with greatest effect. Here is a job—no small job—for post-war management

SYNTHETIC AFLOAT

DON'T LET your thinking of synthetic rubber's transportation horizon be too closely confined to automobile tires, important though this phase is at the moment and for the immediate future Another form of transportation—marine—will be an enormous field for synthetics. Coolant and oil hoses, packings, gaskets. and so on, will be possible outlets for temperature-resisting synthetics Fuel tanks—these for motor cars also—may well be made of synthetics of the type used now in aircraft tanks, and with the well-known safety advantages Vibration-absorbing power-plant mountings will use synthetic rubber as will also various fabrics and decking materials

CONDUCTIVE RUBBER

RUBBER is usually thought of as an excellent insulator of electricity. Yet, as readers of this magazine already know, it is possible to compound rubber so that it assumes desirable electrical conductive qualities. Greatest use at the moment of these conductive rubbers is in safety applications where the material is used to drain off static charges.

Now comes word that panels of conductive rubber have been successfully used as electrical heating units by applying them to or incorporating them in the walls of rooms

FOR FUTURE REFERENCE

PLASTICS bid fair to take over a major portion of the button industry after the war. Introduced pre-war, plastic buttons have been widely proved by military usage, will be more colorful and useful later. . Aluminum will loom large in the packaging field; many answers to problems have already been found, others will follow . Helium, industrially important in magnesium welding, is under close scrutiny in efforts to find additional uses. . . Nylon, in other than textile forms, has a bright future Already mentioned are slide fasteners, switch housings, instrument parts, and other molded objects . Potential electric power from Alaskan rivers is estimated at nearly three million horsepower, which can be developed as the industries of the Territory grow . Higher speed Diesels, burning heavy, low-priced fuels, are now being built Super-charged, such units should make great headway as post-war prime movers on both land and sea. . . Continued planning by the railroads for extended use of stronger, lighter metals point toward safer, smoother, faster transportation. . . Cotton continues to benefit through marriage with plastics. Uses of the union range from expanded textile applications to heavy and strong structural boards. . . Whiskey shortage (more about this on page 151) may go hand in hand with bigger and better poultry, pigs, and cows. Increased industrial alcohol demands result in huge volumes of distillers' by-products which are high in food value for animals.

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of April, 1894)

ENERGY — "The dynamo of this day presents a very good method of changing the kinetic energies of nature, found in waterfalls, in the winds and in the tides, into heat energy. The trolley railroads exhibit the marvelous adaptability of electricity for the transmission of power."

TELEPHONE — "The telephone is the most wonderful discovery of this half of the century. No invention for that period will compare with it in magnitude, in extent and in the largeness of the business which it immediately began to do, and which hereafter it will continue to do."

INVENTORS — "The subject of the inventor and of how he should be treated by the public is a very wide one, on which different opinions may be consistently or at least honestly held. But the enlightened opinion can be but the one The inventor should be encouraged. He is one of the few definitely provided for in the constitution, and the patent statutes are built directly on the provisions of that instrument."

CARBORUNDUM — "Carborundum, the new abradent, according to the inventor or discoverer, is the result of both invention and discovery. It was produced after long research

Molding small Carborundum wheels

and careful and intelligent experimentation, and in its production the inventor made the important discovery that carbon and silica would, under favorable conditions, combine to form a definite compound which was hitherto unknown"

UNDERWATER GUIDE — "Mr. Charles A. Stevenson has been making experiments for locating the position of vessels at harbor entrances, which would be of service when, during certain states of the weather, other observations cannot be easily made. He proposes that a cable . . . be laid down in the sea, and, by changing the electric state of the cable, vessels passing near or over it might be able, by means of a detector on board, to discover that they were in its vicinity. Some experiments show the method to be feasible, since the sea offers no insurmountable difficulty, and he has constructed two instruments which will act through 180 feet of water."

SUBTERRANEAN LONDON — "It gives an impressive idea what subterranean London is fast becoming, to learn that on emerging from the river the new City and Waterloo line will, in its passage up Queen Victoria Street, run for a part of the way underneath the low level main sewer, which in its turn runs along beneath the District Underground Railway. So that at this point in the City we shall have first a busy main thoroughfare, below that a steam railway, then a huge metropolitan sewer, then an electric railway, reaching its terminus at a depth of about 63 feet below the streets."

STREETCARS — "Of the seventy-five miles of track now included in the system of The Baltimore Traction Company, thirty-five miles are operated by electricity, fifteen miles by cable, and twenty-five miles by horses."

WINDMILL — "One of the highest windmill towers in this country, if not the highest in the world, has recently been erected at St. James, L. I. . . The tower is 150 feet high . . The great height of the tower was made necessary from the fact that the spring from which a supply of water was to be pumped was hemmed in by bluffs, and the bottom of the wheel had to be sufficiently elevated to be above all obstructions within a radius of about one thousand feet."

ELECTROLYTIC CORROSION — "Since the introduction of the trolley electric system, considerable has been said and written concerning the subject of corrosion of pipes, etc., by the return current of electricity used in operating the roads. . . Several plans for correcting this evil have been tried, the best results so far obtained being from electrically welding the rails in sections of about two thousand feet."

EMBOSSED WOOD — "One of the latest machines for doing embossed 'carving' in wood . . . does rapid work. Patterns are cut on a hollow brass cylinder which is heated by gas jets from the inside and the wood passed under it under a pressure of several thousand pounds to the inch in width."

PRESSURE SWEEPING — "One of the most notable of the present century's small inventions is an air pump for cleaning purposes. A hose pipe charged with air under fifty pounds pressure to the square inch is turned upon the article or room to be cleaned. It is used in precisely the same way as the water and hose for washing purposes. It is far more effective in its results than brooms, beaters or brushes, as it searches out and penetrates every crevice and cleft in woodwork Some years ago it was said that there would never be an invention that could sweep and dust, but at the present rate of things the problem is practically solved."

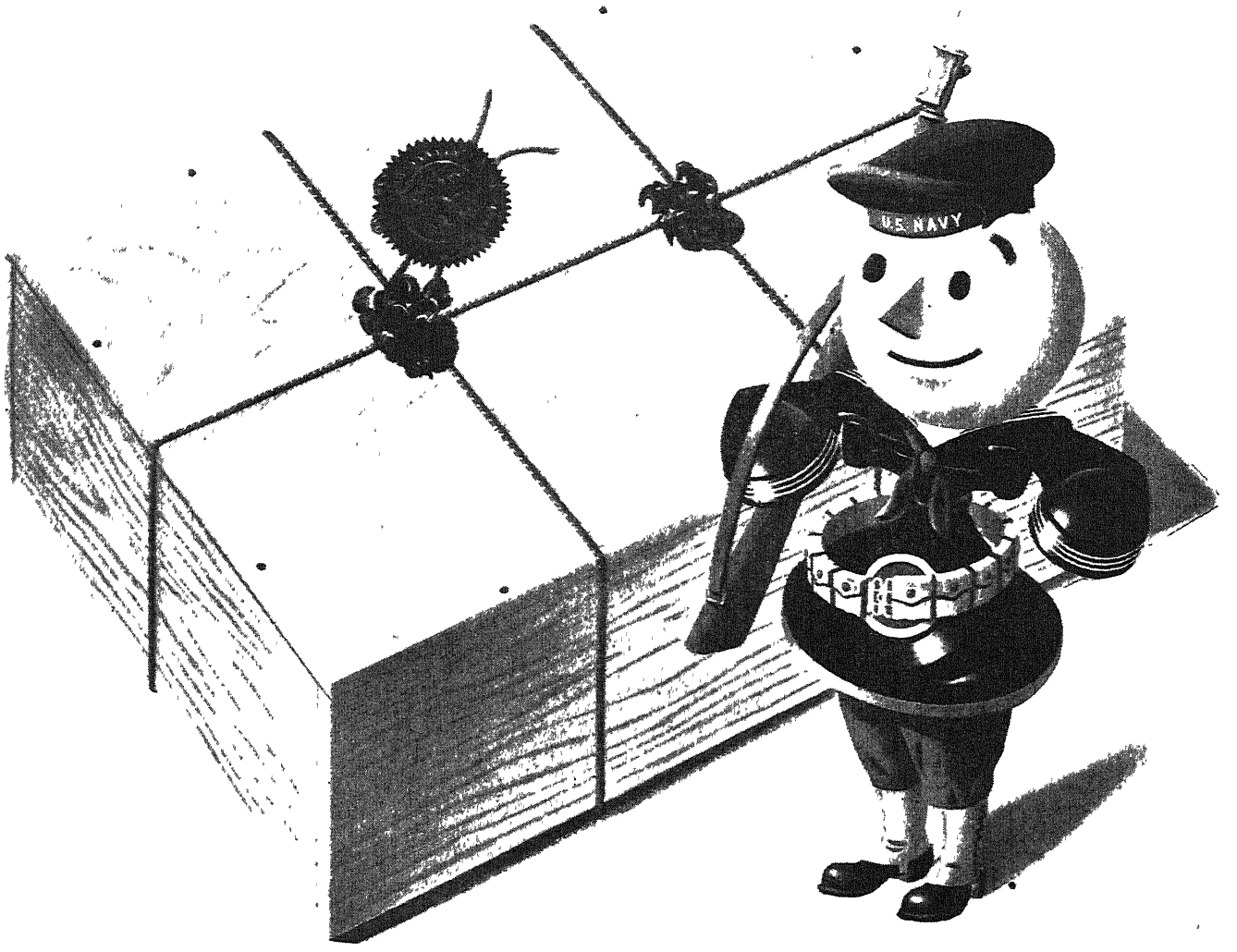
IRONCLADS — "An armored vessel was constructed in the sixteenth century, thus proving that the idea of protected ships is by no means an absolutely new one. This early ironclad was built in the year 1585 by a shipwright of Antwerp during the wars with the Spaniards."

ELECTRICITY IN MEDICINE — "Medical science has called electricity to its assistance in many ways. Various surgical instruments are heated by it; and the use of very small incandescent lamps, which give out practically no heat, permits more extended examination of internal parts than is possible in any other way The use of the microphone has revealed sounds in the heart, lungs, and other organs which have hitherto escaped the most sensitive ear using the ordinary instruments"

ARCTIC ALUMINUM — "Mr. Wellman's American polar expedition, which is now about to leave Norway for the Arctic seas, makes a new departure in Arctic voyages. Both the boats and sleighs with which the party is equipped are constructed of aluminum, and thereby considerably reduces the weight which the exploring parties will have to carry"

JAPS — "The farmer in Japan who has ten acres of land is looked upon as a monopolist."

TUNNEL — "One of the largest railway iron tunnels in Great Britain, at Glasgow—the Mound North tunnel—goes through a large artificial earthen embankment . . . carrying the national gallery and one of the main thoroughfares between the old and new towns and the work therefore had to be carried out with great care. . . The new tunnel is in effect a huge cast iron tube 17 ft. 6 in. in diameter, composed of segments 4 ft. long by 18 in. in breadth, bolted together through flanges 7 in. deep and 1⅞ in. thick. In cutting the tunnel the shield method was adopted."



IT HELPED WIN A GREAT BATTLE

Sealed in this box and deposited in the vaults of the Bell Telephone Laboratories is a special device that helped win a great battle. It is being preserved for its historical significance.

SUCH things do not just happen. New instruments of war may appear suddenly on the battle-fronts. But behind them are long years of patient preparation.

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Concentrating on this job are more than 7000 people in the Bell Telephone Laboratories. Its scientists and engineers and their skilled associates form a highly organized team, experienced in working things out.

Today's work for war had its beginning many years ago when these laboratories were founded as part of the Bell System's service to the public.

BELL TELEPHONE SYSTEM

An Important Message to

Technical Men

The war has carried the manufacturing age to a new peak! Production demands have created technical problems the like of which the world has never seen before! The services of engineers are at a premium. Especially the services of one particular class—executive engineers—*engineers with business training;* engineers who can "run the show."

In these critical times, the nation needs engineers of executive ability *now, today*—not five, or ten years from now! The shortage of such men is acute—even more acute than that of skilled production workers. And company heads, aware of this situation, are offering high rewards to engineers who have the necessary training in industrial management.

Golden Opportunity for Engineers

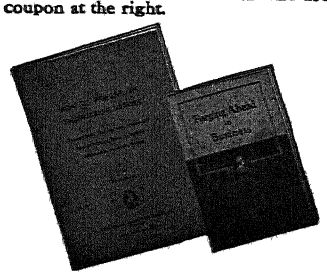
In this new era, the engineer with vision and foresight has a golden opportunity. He will realize that out of today's tremendous production battles will emerge technical men who not only will play a major role in winning the war, but who also will be firmly entrenched in key executive positions when peace comes.

However, before the engineer can take over executive responsibilities, he must acquire knowledge of the other divisions of business—of marketing, accounting and finance. He has of necessity a vast amount of technical training and experience. But in order to grasp the opportunities that present themselves today—to assume leadership on the production front—he must *also* have an understanding of practical business principles and methods.

The Alexander Hamilton Institute's intensive executive training can give you this essential business training to supplement your technical skill.

FREE help for engineers

Ever since the war began, there has been an unusually heavy demand on the part of our technically-trained subscribers for the Institute's special guide on "How to Prepare an Engineering Report". Extra copies of this practical, helpful 72-page Guide are now available and, for a limited time only, will be sent free to all technical men who use the coupon at the right.



134,000 men on the operating side of business have enrolled for this training. More than 37,500 are technical men—engineers, chemists, metallurgists—many of whom are today heads of our huge war industries.

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Please mail me a copy of the 64-page book—"FORGING AHEAD IN BUSINESS" and also a copy of "HOW TO PREPARE AN ENGINEERING REPORT," both without cost.

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Position.....

Home Address.....

"Quotes . . ."

"THE PRODUCTION record of American business during the past two or three years should be a complete answer to those critics, or advocates of a new economic order, who not so long ago advanced the notion that our industrial system is moribund and incapable of meeting the needs of the nation. As events have amply demonstrated, private industry is a very live and potent force, which today is making a mighty contribution to the country's war effort." *Irving S Olds, Chairman of the Board, United States Steel Corporation.*

" " "

"THE STARTLING forward steps that Edison caused by his own efforts could not have occurred in a totalitarian state, whether the label were that of state socialism or fascism or something else. They could have occurred fully only under the unusual state of circumstances which obtained in this country when Edison worked and created." Vannevar Bush, 1943 Edison Medalist.

" " "

"IN GENERAL, ply separation is the biggest single hurdle tire builders have to take in using synthetic." *William S. Richardson, B. F. Goodrich Company.*

" " "

"IT SHOULD be somewhat of a source of anxiety that whatever the post-war plans made by industry, whatever its miracle production record in the war, the future of business depends on the political and governmental atmosphere in which industry is compelled to operate." Raymond Moley.

" " "

"PROPERLY APPLIED incentives have already increased productive capacity to an unbelievable extent. In those places where labor and management have arrived at an arrangement of complete co-operation, production rates more than four times that in other plants where incentive is absent are usual." *James F. Lincoln, President, Lincoln Electric Company.*

" " "

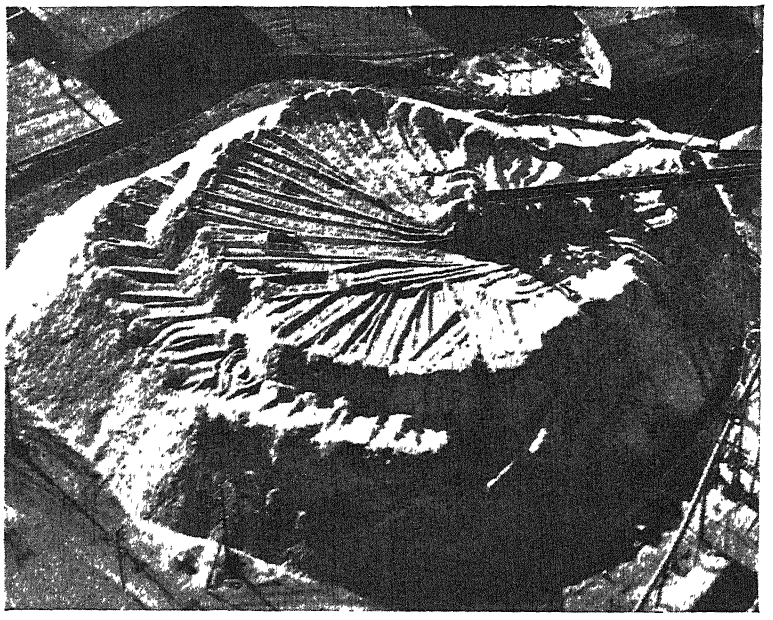
"THE DAY of pioneering in America has not ended Trail blazing now calls for joint effort by government, labor, and industry. Their authority, experience, and vision must fuse harmoniously to achieve success. There must be but one goal—the welfare of the people and the Nation." David Sarnoff, President, Radio Corporation of America.

" " "

"THE WAR electronics of today, about which as yet little can be said, if given proper encouragement and support, will develop spontaneously into the electronics of tomorrow. It may take 10 to 20 years to utilize fully the discoveries that have been made since Pearl Harbor." *Dr. Irving Langmuir, Associate Director, General Electric Research Laboratory.*

CHEMISTRY IN INDUSTRY

Conducted by D. H. KILLEFFER



The 20,000 tons of sawdust in this huge pile can be made to yield a million gallons of industrial alcohol. Note bulldozer on the pile

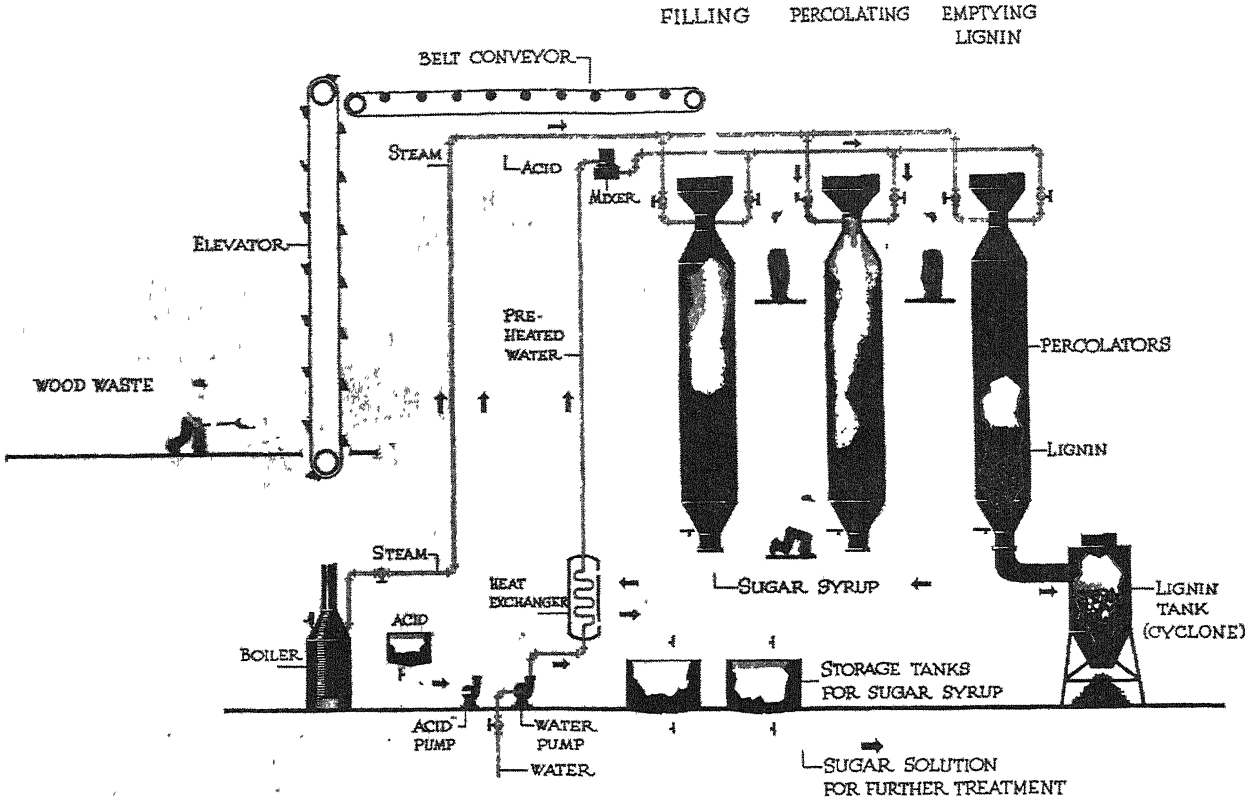
Here's How!

Alcohol Enters So Many War-Needed Products that Present Demands are Six Times Normal Peace-Time Supplies. Conventional Sources are Now to be Supplemented by Alcohol Derived from Wood, Adding New Factors to the Post-War Alcohol-Production Picture

WOOD WASTE may supply the key to the problem of alcohol—grain alcohol—now needed in extravagant quantities to meet the swollen demands of war and of our giant young synthetic rubber industry. Two new developments—new, that is, in America and now soon to be in production—promise cheap alcohol from the sawdust piles of our lumber industry and from the offensive waste liquor from our sulfite paper pulp plants.

Alcohol is the perpetual problem child of industry. With the added complications of war and its immense needs for this useful substance, problems minor in peace undergo tremendous magnification. Interplay of special interests, who find opportunity to forward pet projects in the present turmoil add further to complications. Currently, the most pressing need is to produce quantities of alcohol far beyond anything heretofore contemplated. It is needed to meet the requirements of a mushrooming production of synthetic rubber and at the same time to care for the greatly increased demands that may be considered normal for both military and civilian economies. Proposals shelved or ignored in peace time but of possible value now in contributing to the total output of this essential material are being given large-scale trials to help solve a difficult situation. These new methods, based on utilizing wastes from the lumber and paper pulp industries as sources of alcohol, are being applied on scales which seem likely to resolve all doubts previously entertained about them. They may thus become important factors in post-war industry.

PRODUCTION GOAL SOARS—Alcohol—and by that term is meant specifically grain or ethyl alcohol whatever may be its source—is used by peace-time industry in the United States at a rate of some 100 million gallons annually. Its industrial uses, as distinct from beverage uses, are manifold and may be conveniently divided into three general groups: Solvent applications, in which the extraordinary power of alcohol to dissolve an extremely wide variety of substances places it next to water in usefulness in industry; chemical requirements, taking advantage of alcohol's chemical constitution to produce from it a variety of valuable chemical compounds; and a number of miscellaneous uses. When war struck in 1941, an already enlarged demand for alcohol rose rapidly to an estimated annual requirement of some 350 million gallons. That might be considered a new wartime "normal." Now, the phenomenal development of the synthetic rubber program, requiring alcohol as one of the convenient starting points to manufacture butadiene, has raised the annual production goal to some 632 million gallons. Obviously that quantity is far beyond the range of an industry accustomed to turn out less than a sixth of that amount, and much has been done in the past two years of war to meet this tremendous increase. Part of this has consisted in forcing greater efficiency and output from existing units; a part in building new plants; and finally, as the latest phase of the development, part is to be sup-



Simplified diagram of the conversion of wood to sugar, preparatory to manufacturing alcohol

plied by new processes hitherto neglected.

To understand what has been happening in alcohol, it is necessary to review the industry briefly. Industrial alcohol normally is obtained from three sources: Fermentation of molasses remaining as a waste from the refining of white sugar from cane or beets; fermentation of mashes prepared from the starch of grains and potatoes; and synthesis from the ethylene obtained as a by-product in cracking oil to give higher yields of gasoline.

Molasses has been the principal source of industry's alcohol requirements because it is cheap and plentiful and yields alcohol with minimum trouble and equipment. A gallon of 95 percent alcohol, the normal industrial grade before denaturing, is made from approximately two and a half gallons of molasses at a plant conversion cost of about four cents per gallon of product. To this must be added costs of raw material, of denaturing, and of several other items common to all production methods.

If corn is the raw material, three additional operations are required to convert the starch of the grain into sugar: Grinding, cooking, and malting. These increase conversion costs to about nine cents per gallon of alcohol, quite aside from the cost of the grain. A bushel of corn yields about 2½ gallons of alcohol.

Other farm products and grains can supply the necessary starch, their value for the purpose depending upon their starch content. Grain supplies beverage alcohol but, because the concentration of alcohol for this purpose is only about 50 percent, the distillation equipment of the whiskey industry is much simpler than that with which industrial alcohol plants produce a finished product containing 95 percent alcohol.

Synthesis of alcohol from the ethylene of cracking gases is effected by dissolving gaseous ethylene in sulfuric acid and treating the solution with steam to release ethyl alcohol from the ethyl sulfate previously formed. No comparative cost figures are available but normally alcohol from this source is somewhat cheaper than from others.

WHISKEY INDUSTRY HELPS—The first step-up in alcohol production in 1942 utilized each of these three sources. Molasses supplies were seriously curtailed by the effectiveness of the enemy's submarine campaign. Largely imported from Cuba and other sugar-producing areas, molasses was brought to American seaboard alcohol plants in tank ships, prime targets for submarines. Because the molasses-alcohol plants lacked equipment for handling grain, the initial conversion of the grain to alcohol was largely conducted by the whiskey industry. Thus the whiskey industry could, with existing equipment, receive corn or other starchy grain and turn out 65 to 75 percent alcohol quite readily. This product could then be further concentrated in the more elaborate stills of a few whiskey plants, but principally in molasses alcohol plants, to yield the needed product. In May of 1942 the proposed program was:

Alcohol source	*Annual output*
Molasses	120 million gallons
Whiskey industry, direct from its own stills	100 " "
Whiskey industry, for redistillation	70 " "
Synthesis	60 " "

This represented a reasonably complete utilization of available plants and a corresponding substantial reduction in the output of beverage alcohol. Larger improvement in the import of molasses and expansion of alcohol-producing facilities permitted further increases in the output of alcohol.

The Baruch Committee report on the synthetic-rubber program called for production of a huge proportion of the necessary butadiene from alcohol to be largely made from surplus grain—from a surplus now rapidly dwindling. The facilities of the beverage alcohol industry were commandeered and expanded to even greater production for this purpose. Expected consumption of alcohol for rubber during the present year is more than three times the whole normal peace-time consumption of industrial alcohol in the United States.

That increased demand plus other burdens on alcohol has swelled our 1944 alcohol budget to:

Synthetic rubber	328	million	gallons
Direct military uses	48	"	"
Lend-lease	59	"	"
Indirect military and civilian uses	165	"	"
Anti-freeze	32	"	"
Total	632	"	"

Clearly, such an enormous demand

precludes entirely the diversion of any of the precious product from current production for beverage purposes and requires every possible facility to be fully utilized. What is more important, this extraordinary demand provides a basis for using two sources of alcohol which have hitherto been neglected in this country.

Conversion of the cellulose of wood waste to sugar by treatment with acid, and subsequent fermentation of this sugar to alcohol, was practised in World War I in Louisiana, but the process was abandoned after the extraordinary demand of that war period ceased Subsequent improvements of the process abroad led to tests on a pilot-plant scale in this country, but not to its adoption on a commercial scale under peace conditions

The present need for production has ended argument about the economy and competitive position of the process Consequently, the so-called Scholler-Tornesch process is being installed on a substantial scale for the first time in this country. The operation of the proposed plant will yield definite answers to many questions about it which have hitherto been controversial. Primary improvement is in the method of treatment of sawdust or shredded waste wood with acid. Results obtained with the process in Europe and on a small scale here indicate production of 50 to 60 gallons of alcohol per ton of dry wood substance, compared with 25 to 30 gallons from American practice in World War I. In Europe the food value of yeast, a by-product of the fermentation, possesses a value greater than any yet realized here.

The paper industry has long wrestled with the problem of disposing of the waste liquor produced in the manufacture of paper pulp by the sulfite process The problem arises because this waste is a serious nuisance in streams and is difficult to dispose of otherwise. It contains the lignin of the original wood, a certain amount of sugar produced from the wood's cellulose content by the action of the acid treating liquor, and a residual amount of the original sulfite acid liquor which goes through the process unchanged. Recovery of the liquor for re-use is impractical because of the high percentage of impurities extracted from the wood. Various proposals to utilize this waste have been only partially successful, but such is the pressure on paper mills to keep this contamination out of streams that a large share of any cost of disposal can be properly charged off to the paper mills' operation rather than to the value recovered.

EFFICIENCY STEPS UP—In the new alcohol projects based on sulfite waste liquor, the acidity of the liquor is first materially reduced by the addition of lime, which precipitates calcium sulfite that can be re-used in preparing fresh liquor. The lignin is next removed and is available as a constituent for plastics or for other use. The residue is a dilute solution of sugars capable of conversion to alcohol by fermentation and subsequent distillation. Improvements lately made in the process increase its efficiency by changes in the methods of cultivating and introducing the yeast required for the fermentation.

Still somewhat problematical is the value of the lignin by-product from both of these processes. Obviously useful, this plastic substance has yet to attain the full commercial stature to which it is apparently entitled. So great is the quantity of lignin available from these alcohol processes that a difference of a cent a pound in its selling price will make a difference of as much as ten cents a gallon in the cost of alcohol.

Both of these processes have much to recommend them. Primarily they utilize waste products which now are nuisances. If they accomplished no more than this scavenging function they would merit serious consideration, but since they also yield a badly needed product their value is immensely increased. Operation on a substantial scale under American conditions will answer questions and clear up reservations heretofore held about both processes. If those answers are favorable, the processes will undoubtedly be operated after the present emergency has passed —may even become important factors in industry. Their promoters are confident of this result.

Prohibitionists delight to see facilities for making beverage alcohol no longer available for that purpose, actually gone to war. Tax authorities worry over a tax to substitute for the one no longer productive on whisky. Industry puzzles over the vexing problems of providing alcohol in quantities scarcely imaginable a few years ago Synthetic rubber production must have more alcohol Smokeless powder production requires a small ocean of alcohol in admixture with ether to convert fibrous nitrated cotton to the jellylike mass that is formed into grains for guns. A thousand tinctures, essences, and pharmaceutical preparations consume other quantities of the vital solvent before they can meet medical needs of civilians and fighting forces alike. Motorists need more millions of gallons of alcohol to replace and supplement anti-freeze agents now performing more essential war jobs.

Alcohol is vital for these and all manner of materials and processes bound for war. And war will not wait.

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SYNTHETIC MENTHOL

Made from Thymol, A Coal-Tar Derivative

A NEW method of synthesis of menthol, odorous constituent derived from peppermint oil, promises independence from Japanese producers of this useful material. The synthesis requires thymol, derived from coal tar, as the starting material and produces unwanted materials at intermediate points during the four-step process. Each of the by-products can, however, be separated and returned to an earlier stage in the process for reconversion. The final product is what is known as racemic menthol. This differs from the natural product in being a mixture of equal parts of two compounds whose chemical structures are mirror images of each other. Only one exists in the product of the peppermint plant. Both British and German Pharmacopoeias recognize the synthetic compound but that of the United States does not.

FUNGICIDE

Can be Used on Textiles Or on Growing Plants

REPORTED to have high effectiveness against fungi, which cause an annual loss in the United States estimated to be over a billion dollars, a new organic chemical, 2,3-dichloro-1,4-naphthoquinone, is at the same time harmless to plants. The new compound can be used on cotton fibers and textiles to prevent mildew and the accompanying rotting of the fibers, and it is also valuable in combatting the numerous fungous pests and diseases which destroy crops. For both applications it possesses advantages over sulfur and mercury and copper compounds now used for these purposes. Vital, too, is the fact that strategic metals are not consumed in its manufacture.

CRANBERRY WAX

Offers Useful Properties in Emulsions

THE WASTE of cranberry canneries yields a wax, ursolic acid, that is finding wide usefulness in the present period of shortages. Not only is ursolic acid a useful wax, but it is also proving itself as an emulsifying agent in such products as mayonnaise and cosmetics. It possesses the invaluable property of raising the melting point of other waxes with which it may be mixed. The waxy acid occurs on the skin of the cranberry and can be recovered from the waste left from the manufacture of cranberry sauce where this operation is carried out on a large scale.

PAINT IN CRIMINOLOGY

Tiny Flakes Used in Auto Identification

IDENTIFICATION of automobiles as to make and year is accomplished by scientists for the Federal Bureau of Investigation by analysis of paint. Even a tiny flake of the finish from a car often supplies enough evidence for its identification. If this is not possible, at least the number of possibilities is limited to an important extent by the findings. Spectroscopic and microchemical analyses supplement microscopic examination, which reveals the number of coats and mixtures of pigments. Comparison with files of paint samples used on cars of various years, makes, and models frequently completes the identification. Tiny fragments left at the scene of a hit-and-run accident thus may lead, through chemistry, to the guilty party.

Versatile Indium

Once Valued at $20,000 an Ounce, Indium Now Sells for $7.50. It's Peculiar Properties Open Wide Fields of Use in High-Speed Bearings, Solders, Jewelry, and as a Hardening Element in Non-Ferrous Alloys. Not on the List of Critical Metals

By KENNETH ROSE
Engineering Editor, *Metals and Alloys*

When our Army Air Corps pilots fly American planes to meet Hitler's Messerschmidt's and Tojo's Zeros, they depend upon whirling propellers and roaring motors for victory—even for life itself. That they may safely count upon their ships is shown by the results of each day's battles. Yet the endless whirling of the propeller, upon which so much depends, is in turn dependent upon a metal which ten short years ago was still a laboratory curiosity—indium.

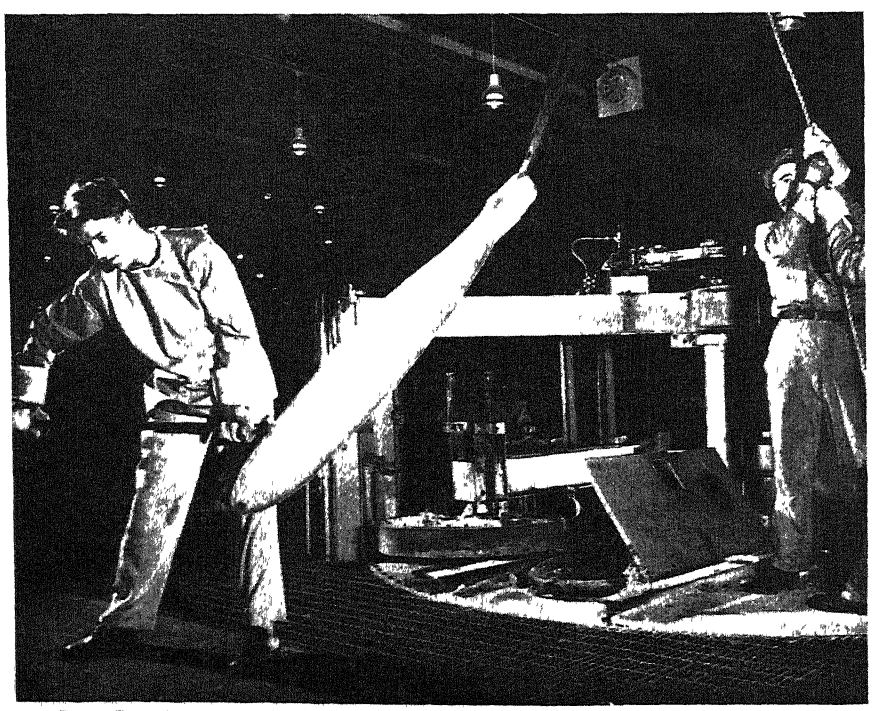
Few machine parts have heavier demands made upon them than aircraft bearings. They must support shafts that transmit hundreds of horsepower at high rotational speeds, with human life in the balance. Yet they must be light in weight, durable, and resistant to corrosion from the lubricant used. The development of the type of bearing now widely used is a story of engineering achievement.

Steel itself would be completely unsatisfactory for any sort of high-speed bearing, but advantage is taken of the strength of steel by using a bearing shell of that metal. The greater resistance to deformation of the steel, compared to the most common bearing metals, permits the use of less of it, thus reducing weight while maintaining the required rigidity. However, the bearing must provide resiliency also, and what better material could be used for this purpose than silver, one of the most ductile of the metals? This silver-steel composite, utilizing the best features of each metal, is being applied to other equipment, as well as to aircraft engines, when a high-duty bearing is needed.

But now another problem appears. Silver, in contact with the moving part, would tend to heat rapidly, also to bind or gall. Another metal therefore is added to provide anti-friction properties, and for this purpose lead is ideal. The lead is electro-deposited as a thin plating over the silver. The result is good, but not quite good enough. The lead film tends to corrode under the action of the acids formed by breakdown of the lubricating oil. For the final touch, indium, a metal softer than lead but more corrosion-resistant than silver, is plated over the bearing surface, then diffused into it.

The resulting bearing, combining the strength and stiffness of steel, the elasticity of silver, the "greasiness" of lead, and the corrosion resistance of indium, has removed aircraft bearings from the list of items which must be periodically replaced in modern planes. A bearing which gave 200 hours of service was formerly considered a good bearing. These new bearings have a service life equal to that of the rest of the motor—thousands of hours.

It might be imagined that the fabrication of this seemingly complex kind of bearing would be a problem taxing the ingenuity of the production engineer, but actually it is quite simple. The steel shell, after proper cleaning, is given a light plating of copper over the surface to be built up. This deposit of copper is not a part of the bearing structure, but merely assists the bonding of the steel to the silver layer to follow. A thin plating of nickel may be added over the copper for some types of bearings.



A modern hollow steel propeller blade undergoing quenching after heat treatment. Many blades of this type are now being indium plated for durability

THICKNESS IS IMPORTANT—The silver is then plated on, the thickness of the deposited layer being a matter of design. Sufficient metal must be laid down to provide resilience, yet not so much that the malleable silver will deform under the thrust of the moving parts. Thicknesses may be of the order of 0 02 to 0.03 inch. A machining operation usually follows, with the internal diameter made slightly oversize to allow for the succeeding deposits.

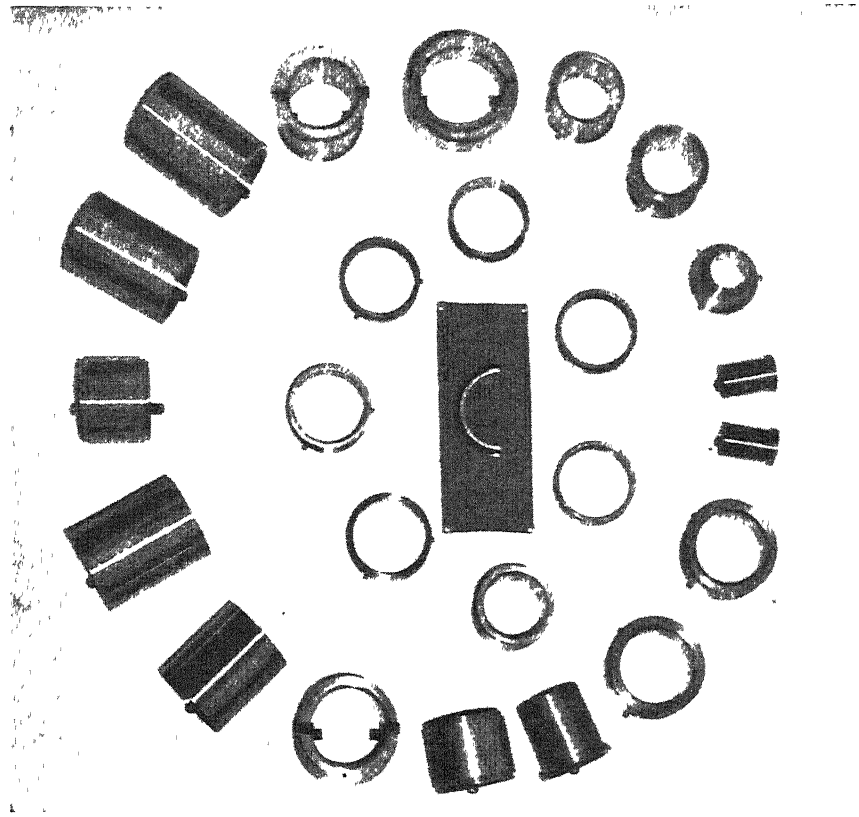
The silver surfaces are then slightly roughened by sandblasting and a thin film of lead is deposited, again by electroplating. This plate is about 0.001 inch thick, and the plating process may be so controlled that the bearing is brought to exact size, eliminating the need for final machining. If size is not controlled by the plating, a rolling operation follows.

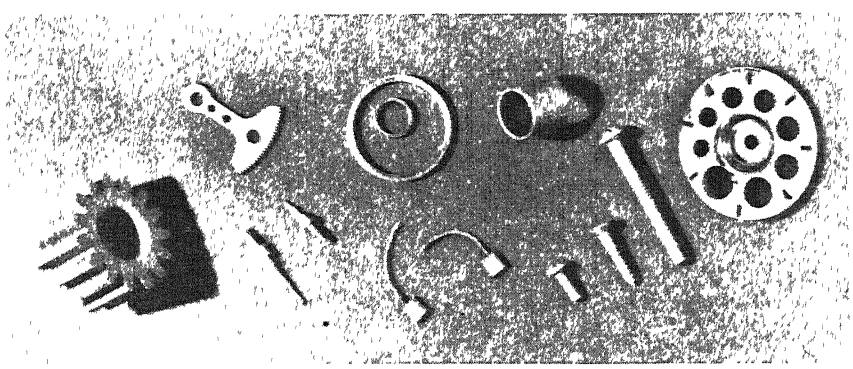
Indium now enters the picture to complete the bearing by conferring its own peculiar properties upon the actual wearing surface. Although indium is softer than the lead plating, it gives greater hardness to an alloy when combined with a number of nonferrous metals. It also melts at a low temperature—only about 100 Fahrenheit de-

grees above the boiling point of water. It alloys readily with most metals. Taking advantage of these properties, a "flash" plating of indium, perhaps a few hundred-thousandths of an inch thick, is laid down over the lead, and then diffused into the lead plate by heating in an oil bath. The bath is heated to about 350 degrees, Fahrenheit, and the indium, which melts at 311 degrees, fuses and immediately alloys with the surface of the lead. The other metals in the bearing are unaffected by this moderate heating.

Bearings other than this composite are being improved with a coating of lead, followed by a flash plate of indium. Bronze bearings are being produced with a light plate of indium diffused into that metal also. Shortly before the outbreak of the war the automotive industry had recognized the value of indium diffused into the surface of heavy-duty bearings of various types, and the resumption of manufacture of passenger cars and trucks for civilian use will surely see a wider use of indium-treated bearings.

REJUVENATION—Aircraft bearings are now being rejuvenated by replating with indium. For this purpose a wire anode of pure indium is used, the bottom of the bearing is sealed, and the cavity filled with the plating solution. A diffusion treatment follows, and the bearing can be replaced in service.





Above: Miscellaneous small bearings are made more durable by indium plating on wearing surfaces. Left: Tarnish resistance is imparted, by the same process, to such parts as small spur gears, instrument racks and pinions, screws, electrical contacts, and so on

Manufacture of hollow steel propeller blades gave indium another opportunity to serve the aviation industry. Here the problem was slightly different—to produce a coating which would protect the steel and at the same time would not greatly lower its fatigue resistance. Many different kinds of coatings had been tried, but each one either wore through at the leading edge during the whirl tests, and permitted the remaining film to peel, or the fatigue strength of the steel was lowered to an excessive degree.

The coating finally developed to meet the requirements was a zinc and indium combination. It was found that this coating, after a whirl test for 4½ hours, followed by a 4-hour salt spray test, showed no trace of corrosion. Fatigue resistance was lowered less than 4 percent. In fact, it was found in long-continued service tests that, even when the coating appeared to be worn away, sufficient zinc-indium alloy had been driven into the surface of the steel to continue the protection.

Production of the coating involves only a careful cleaning of the steel and zinc plating, followed immediately with an indium plate. The indium is then diffused into the zinc film, increasing the adherence of the plate.

These hollow steel propeller blades make use of indium in another form also. Certain brazing operations in the assembly of the propellers employ a gold-indium brazing alloy, prepared for this purpose as a powder. Here again the soft metal indium, alloyed with gold, another soft metal, provides a hard, strong brazing material. Indium also possesses to a high degree that property known as "wettability," so important in solders and brazing compounds.

Wettability makes indium an important ingredient in several soft solders. Compositions of 3 percent silver with 1 to 2 percent indium, remainder lead, are on the market, and show superior properties for some applications. Indium not only wets metals, but glass as well. For this reason the gold-indium alloy referred to before is useful in the construction of several types of electron tubes, in which metal must be soldered to glass. The alloy is too expensive for general soldering uses.

An important factor in the use of any material is price. While some metals, because of unique properties, find industrial uses in spite of extremely high cost, the number of possible applications increase rapidly as price falls. When samples of indium were first prepared in 1867, a price of about $20,000 an ounce was placed upon them. Fifty years later the price was still high—$300 an ounce—with no takers. Eight years ago, with industrial applications of indium in dentistry and in jewelry a few years old, and other prospects foreshadowed by research, the price was $30 an ounce. With the coming of the war, and indium's value in aviation recognized, the metal was selling for $12 a Troy ounce. It has achieved the distinction, shared with only one or two others, of two price reductions during wartime. Indium Corporation of America has lowered the price to $10, then to $7.50, a troy ounce, since the outbreak of the war.

ONLY SMALL QUANTITIES NEEDED—While even this price entitles it to a rating with the precious metals, indium has a great advantage in that very small quantities accomplish large results. For most applications a thin film of the metal, perhaps only a few hundred-thousandths of an inch thick, can be plated onto the surface of the work, and this film diffused by low heat. When used as an alloying element, as in solders or as a hardening agent, a few

percent will usually be quite sufficient.

It is interesting to note that, while the use of nickel, cobalt, tin, and even copper and iron are restricted, indium is not a critical metal. There exists a potential supply of probably 500,000 ounces per year.

Aside from its present uses in aviation, indium offers possibilities in the jewelry industry. A white gold that is more corrosion-resistant than the present metal can be produced by alloying with a small percentage of indium Larger amounts produce a blue gold In both cases a desirable hardening of the gold accompanies the coloring effect. Sterling silver with indium diffused into its surface resists oxidation and sulfation. Other precious metal alloys are known.

Indium compounds are used in preparing the plating baths for these applications. The most widely employed is the cyanide bath, containing indium trichloride, which lays down a good plate under most conditions. It has good throwing power, and has no critical conditions of temperature or current density. Fluoroborate and sulfamate baths are available also.

Indium oxide can be used for tinting glass Shades ranging from light yellow through deep amber can be produced by varying the oxide content.

Several present important uses of the metal are veiled in military secrecy Several others are marking time until post-war markets are available. When war-time restrictions upon information and business are ended, indium may be expected to step into the automotive and stationary engine fields and into the machinery and tool industries; to play a more important role in jewelry; to enter the printing trades as a facing for electrotypes; to develop with the solders, brazing alloys, and other low-melting combinations, and as a hardening element in other nonferrous alloys. The price will probably go still lower. Its valuable combination of properties may make it a necessity to some of those new products and tools of which as yet only hints are given. Its future can scarcely be other than bright

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BROKEN TOOLS

Removed by Electrochemical Means

ONE OF the most annoying problems in metal-working operations is the breaking of drills, taps, and reamers in such a way that part of the tool remains lodged in the work. Because this situation often means scrapping of the part or the tedious removal of the tool by prying and gouging, the recent development of a quick, automatic, electrolytic method for broken tool removal represents a real contribution to increased production.

The best solution for the removal of steel tools from aluminum castings was found to be a saturated solution of ammonium sulfate in water. The parts may be immersed in a tank containing that solution, the whole metallic system being made the anode in an electrical circuit of 24 to 50 volts potential. Under these conditions the steel rapidly dissolves, but the aluminum quickly receives an anodic coating of aluminum oxide (like the film produced by the commercial anodizing process) and is thus protected against dissolution.

Where batch immersion is not practicable, a special electrolytic apparatus is used by which the electrolytic action will be localized over the area of the broken tool to be removed.

Examination of the resulting hole, bore, and so on, will show complete absence of any corroding effect on the aluminum. Walls will be left smooth and threads intact and bright. All holes will conform to tolerance specifications when gaged.

MICRORADIOGRAPHY

Shows Grain Structure Below the Surface

MICRORADIOGRAPHY is a new engineering tool by which the microstructure of metals below the surface can be determined. Its uses are growing rapidly as metallurgists become familiar with its possibilities in telling them things of practical value about the internal structure of materials or parts, incapable of determination otherwise.

Ordinary metallography permits the study of just the *surface* grain structure of metals, and then only after tedious polishing and etching. Ordinary X-ray inspection, on the other hand, provides a means of observing internal inclusions, flaws, pores, and so forth, but not the grain structure.

The technique of microradiography comprises radiographing a specimen of the material on an extremely fine-grained photographic film and then enlarging the resulting image to whatever magnification seems desirable. Ordinarily it is necessary to employ several X-ray tubes, one for each type of alloy, according to the X-ray absorption coefficients of the alloy constituents encountered R C Woods and V C. Cetrone, of Picker X-ray Corporation, however, have developed a technique that uses a *single* X-ray tube of the tungsten-target type and a variation of the voltage for each situation.

Results have been achieved comparable to those conventionally obtained with several tubes that have to be changed for each job In addition, extreme flexibility in selecting individual alloy constituents of the metal tested can be enjoyed.

ZIRCON REFRACTORIES

Proved Satisfactory in Aluminum-Melting Furnaces

DESPITE the relatively low melting temperatures developed in them, aluminum-melting furnaces present a sizable refractories problem. High-heat-duty firebrick, super-duty and high-alumina refractories fail, even at operating temperatures as low as 1220 to 1300 degrees, Fahrenheit, because of penetration by metal, oxide, or vapor, or a thermit reaction with iron oxides and silica, or mechanical abuse when charging and cleaning the hearth and side walls of the furnaces

Over the past two years considerable successful experience has been recorded in the use of zircon refractories for the construction of the working hearth in reverberatory or open-hearth aluminum melting furnaces, according to Chas. Taylor Sons Company. Zircon (zirconium silicate) refractories have the peculiar property of not being "wet" by aluminum metal, dross, or oxide. Their apparent specific gravity is 4.46, and thus spalls or small particles of brick will not float in the common aluminum alloys.

In the case, for example, of one ten-ton furnace at an aircraft engine plant, 13 8 million pounds of aluminum were melted on a zircon hearth in a ten-month period with very little erosion and no significant harm to the refractories. The average life of firebrick hearths in this same plant was 10 to 12 weeks, with frequent shutdowns for cleaning and repair.

ALLOY-CLAD

Metal Sheet Presents New Advantages

THE AIRCRAFT industry has long used for many exposed surfaces a sheet and plate product (known as Alclad, Pureclad, and so on) consisting of a strong aluminum-alloy core clad with pure aluminum. The pure aluminum surface provides the corrosion resistance and the alloy core the strength and toughness required for such service.

A new product has just been introduced by Reynolds Metals Company that is believed to have certain advantages over the currently used aluminum-clad 24-S sheet—chiefly, superior formability in the annealed and solution-treated tempers and a minimum yield strength 46 percent higher.

Known as R-301, the new material consists of a high-strength core alloy covered on each face with a corrosion-resistant intermediate-strength *alloy*. The material contains the same elements as are present in the widely used 24-S alloy—aluminum, silicon, iron, copper, manganese, and magnesium This is important since inadvertent scrap admixture of the two materials will thus not lead to serious contamination.

The percentage of alloy cladding will vary with the gage of sheet as protective requirements indicate. Corrosion resistance is of the same order as, although measurably inferior to, the conventional pure-aluminum-clad product.

Unlike the 24-S alloy, the new material can be formed, hammered, rolled, or drawn *and then* solution heat-treated to develop maximum tensile properties in the hardened condition. The higher hardness of R-301 sheet in comparison with pure aluminum-clad surfaces makes it more resistant to the scratches and abrasions that often lead to fatigue failure of the part.

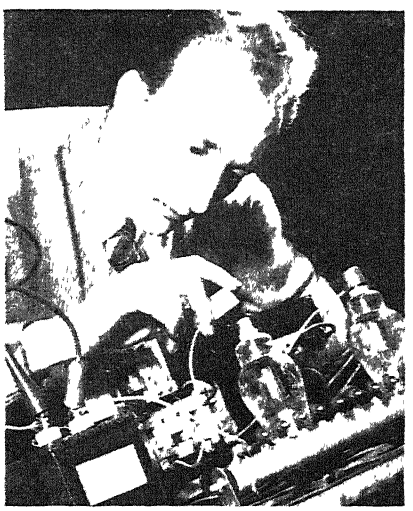
Welding In Production

Electronic Control Methods have Increased Reliability and Speed in Welding, Bringing Precision Operations to the Assembly Line. Factors Governing Quality of Welds Can be Held Automatically Within Predetermined Limits. Magnesium Now Welded Electrically

By VIN ZELUFF
Assistant Editor, *Electronics*

ATTACHING two pieces of metal together without bolts or rivets is an old problem, for a long time solved only by the village blacksmith at the hot forge. Then came oxy-acetylene torch welding and a tremendous increase in welded products, followed in turn by arc welding and electrical resistance welding of the more common metals. Then electronics stepped into the picture and made electric welding a reliable and precision metal-joining process even for structural parts under stress and severe vibration. In addition, metals that had never before been welded on a production basis succumbed to the welding process. Today, electronic control has made resistance welding a production-line stand-by and has also aided greatly in arc welding control

Briefly, resistance welding involves applying pressure to two or more pieces of metal and then heating the surfaces in contact by passing an electric current of a definite value through the joint for a definite length of time. The pressure and the electric current, which, together with the time element, are critical factors in producing satisfactory welds, are applied by means of two copper alloy electrodes or rollers designed according to the type and shape of the material being welded. The amount of current flow is controlled and, when it is stopped, the pressure is maintained until the melted metal sets and the pieces are bound together.



Interior of an energy storage welding control made by Westinghouse and used for welding aluminum parts

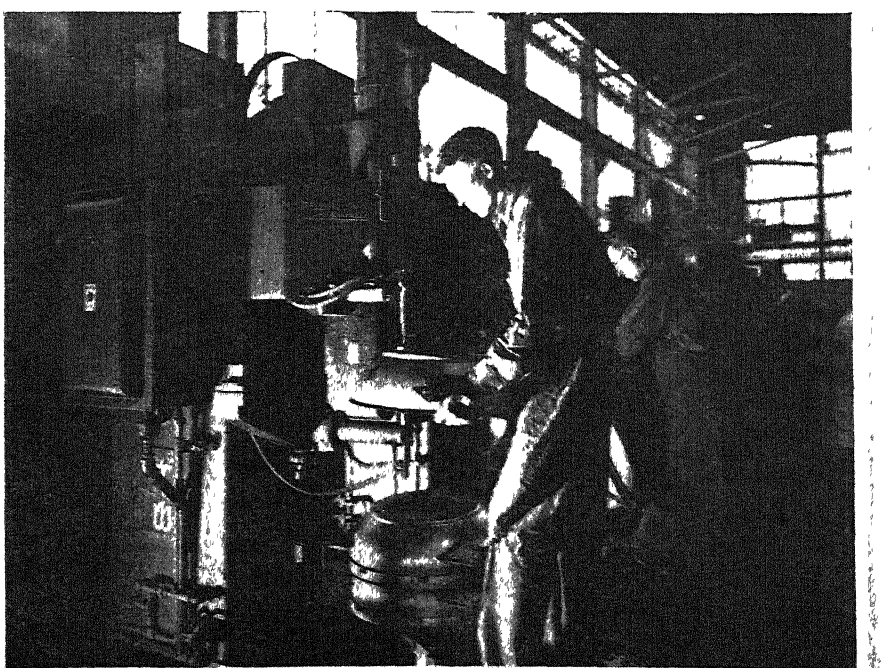
As a metal processing method, resistance welding is not new but it was not in general use until after the addition of electronic control some 20 years ago. Today, the vastly improved versions of electronic welding machines have contributed tremendously to the metal fabrication industries so necessary to the war effort

To soften metal at the point of contact, the current through the work may be 1000 amperes, a low value, and may be as high as several hundred thousand amperes. The magnitude of the current flow and the length of time of flow are the two important factors that can be controlled by vacuum tubes to determine the quality of the weld. So precise, in fact, is the control permitted by electronics that materials such as aluminum, stainless steel, and magnesium, that never before could be welded, can now be successfully welded on a production basis

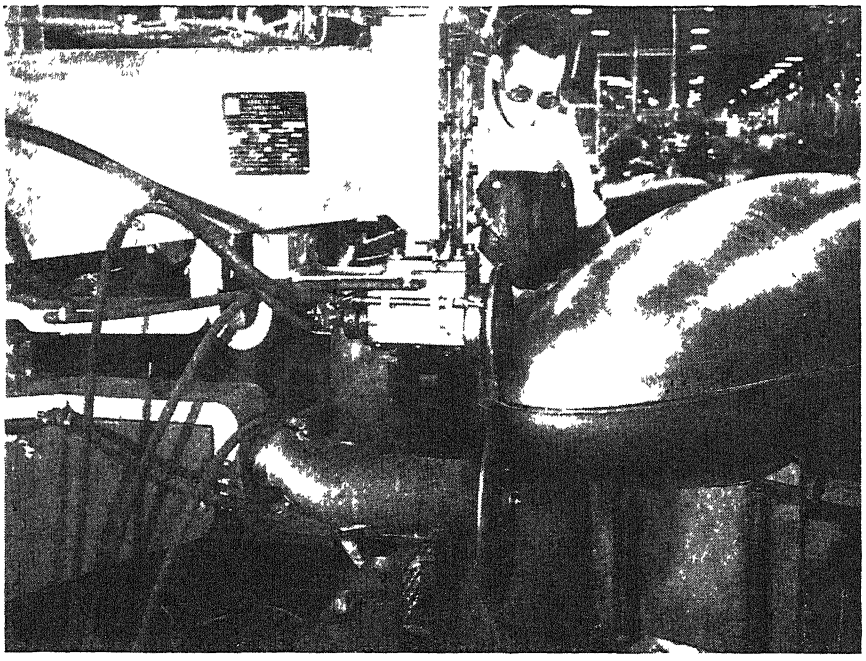
1000 TIMES A MINUTE—One method of obtaining the high current necessary for resistance welding involves the use of a step-down transformer with its primary winding connected to the power line through a current-interrupting unit. This device must be capable of interrupting the heavy current as often as 1000 times a minute without breakdown.

The first electronic interrupters were thyratrons—large glass electronic tubes filled with mercury vapor and having a heated filament. These couldn't handle much current without burning out, hence had to be used in a trick circuit where they shorted the secondary of an extra series transformer in the primary circuit of the welding transformer. After development of the sealed-off, water-cooled ignitron tube—a metal affair that looks like a metal can with a few wires or terminals sticking out—current limitations were no longer a problem.

The ignitron tube consists of a metal container or envelope with a pool of mercury at the bottom. A metal plate



A sequence timer controls current and strokes per minute on this spot-welding job



Two halves of a leak-proof tank being welded at a rate of 60 inches a minute

or anode is suspended an inch or so above the pool, and a special igniter rod dips into the pool. Electrons can flow from the pool to the anode only when an arc is started in some way. An igniter rod does this and does the job so well that the arc is deliberately allowed to go out at each current zero in the A.C. cycle, and rekindled a half-cycle or more later, depending upon how much of the cycle is to be used. The igniter requires only a low voltage and current for this purpose—so low that a small radio-type potentiometer is used to adjust the welding current. Prior to the days of electronic control, huge tap switches were used on welding transformers to adjust the current.

VOLTAGE COMPENSATION—By the addition of other vacuum tubes, electronic resistance welding controls automatically compensate for variations in line voltage and for the amount of metallic material between the jaws of the welding machine. This permits consistent welds to be made by unskilled operators, even though the material varies in thickness or the line voltage fluctuates wildly due to power demands of other electrical equipment in the plant.

For large resistance welders drawing thousands of kilowatts, electronic controls have been developed to operate directly from a 2300-volt power supply system, with resulting savings in copper and in transformer costs.

In welding such low-resistance metals as aluminum and its alloys, the welding current demands are extremely high, and a severe burden is placed on plant distribution systems unless power-factor correction is used. This situation is improved by drawing lower current and storing it over a comparatively long period of time, then discharging it as the required large current in a short space of time. This process is called energy storage welding.

The advantage of energy storage welding is that the power demand is small and is taken from a three-phase line instead of from the single-phase line usually required by A.C. welding. It is used in two forms—one in which a D.C. source (such as a low-voltage rectifier) stores energy magnetically in the primary of a special welding transformer, and the other in which a high-voltage rectifier charges a bank of capacitors. The time required to charge either the special transformer or the capacitors is long compared to the discharge time, and the power demand is very low compared to that required by taking the energy directly from the power line. To obtain the necessary flexibility and preciseness of control, with both methods, electronic tubes are used in the rectifiers and associated controls.

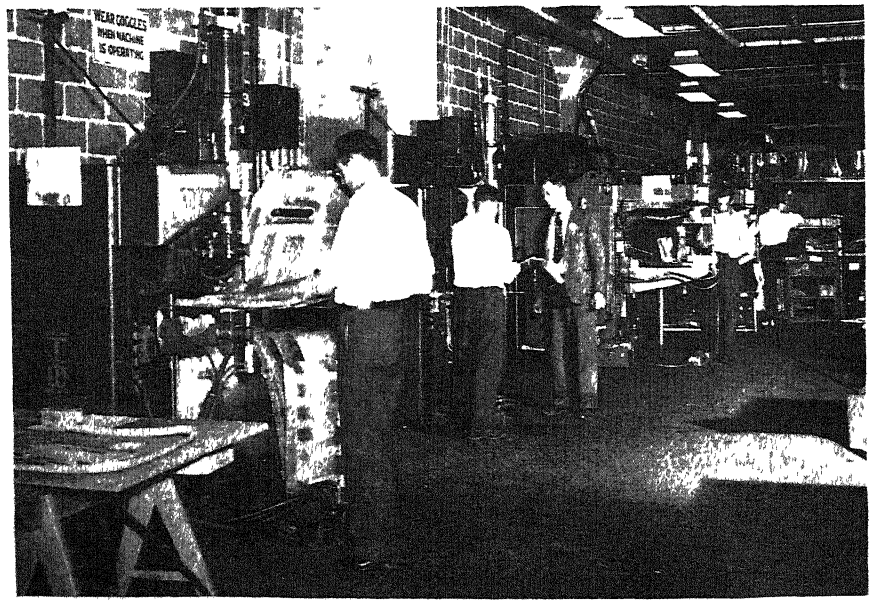
With precision electronic control, resistance welders have produced numerous reliability records. For example, one plant has turned out 21,000 evaporators containing 1,250,000 spot welds, 22 miles of gas-tight seam welding, and 94 miles of intermittent seam welding without a single unit being rejected because of faulty welds. Such production records can be hung up even under such difficult welding conditions as when a large numbers of welders are supplied from a common power line and two or more pull the voltage down by drawing their tremendous peak currents at the same time.

An important electronic aid for maintaining weld quality is a newly developed weld recorder that can be used with any type of welding control. This instrument, as made by General Electric Company, records the variations of the electronic input for each spot weld. When a weld exceeds the safe limits based on predetermined settings of the recorder, a bell gives a continuous audible signal and the welding machine is turned off automatically.

NUMEROUS FACTORS — High-quality welds in resistance welding are obtained by accurate control of electrode condition and cooling, electrode pressure, surface and character of metal to be welded, strength of current, timing of current for each weld, and shape of current wave for each weld. The heat developed in the weld zone, and hence the quality of the weld, is proportional to the square of the current, the resistance of the weld zone, and the time; the electronic weld recorder gives control over all of these variables.

Structural parts that are under pulsating stresses, as in bodies of aircraft, rail cars, automobiles, buses, trucks, and trailers, are being fabricated with greatly increased use of welding. Failure due to a defective weld can be serious, but the increasing use of electronically controlled spot welding, even for structural parts of aircraft, proves the reliability of the method.

Another promising welding development is radio-frequency welding, which is being used in the aircraft industry to weld paper-thin sheet metal to metal structural parts. This process provides air-tight joints with full mechanical strength. It is also being used to weld threaded stud bolts to flat boiler plates.



Spot-welding aluminum parts with a synchronous G-E thyratron control

to weld bolts and rods of dissimilar metals end to end with a smooth joint, to weld metals such as magnesium that heretofore were unweldable electrically, and to produce many other difficult welds. Electronic tubes are used here to generate the actual power used for welding, but little has as yet been revealed regarding circuits and equipment because existing equipment is used exclusively on war production.

In this type of welding, practically no heat is produced except at the welding surface. In one test, a thermocouple placed as close as possible to the joint being welded showed a maximum temperature rise of only about 10 degrees The high current flow takes place for such short intervals that the heat is concentrated right at the welding surfaces where it is needed, and is not conducted to surrounding areas.

Although electronic tube control of welding operations has had to contend with the usual difficulties encountered by radically new processes, its worth in the metal fabrication industries has been tested and proved by the demands of the war-production program. Higher and more reliable weld quality, higher rate of production, reduction in labor costs through the use of less skilled workmen, and the ability to weld materials not capable of being welded by any other means, are factors that industry considers essential for peacetime production progress.

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BUMPLESS RIDES

Promised by Development of War Tank Equipment

PRINCIPLES that enable American tanks to fire on-the-run with devastating effect quite possibly will provide "floating" rides in high-speed trains and other vehicles, according to Westinghouse engineers. Actual development work on these electronic applications has been started. Calculations show that the power required to stabilize the vertical movement of a railroad coach is only about three horsepower. The servomechanism necessary to accomplish this is small enough to fit into an overnight bag.

Curiously enough, the servo-mechanism to stabilize a railroad car will require about the same power and be about the same size as that required for an automobile. The equipment required depends on the weight of the object multiplied by the square of the up-and-down movement of the road. The automobile is much lighter, but the vertical movement is several times that experienced by a railroad car.

OIL HOLE INSPECTION

Checked With Mirror and Photoelectric Cell

THE JOB of determining whether an oil hole drilled longitudinally part way through a shackle bolt exactly meets another oil hole drilled into the bolt from the side is being performed automatically by a machine that utilizes simple photoelectric principles. A beam of light is reflected from a mirror into the longitudinal hole while the bolt is revolved one complete turn by a rubber-tired driving wheel. A phototube is mounted adjacent to the side hole If the phototube does not receive the required amount of light at that point in the revolution when the side hole is facing the phototube, a rejection mechanism is actuated. Either imperfect alinement, blocking by metal particles or insufficient depth of drilling can lower the amount of light making the right-angle bend through the bolt and cause rejection

CRANE STABILITY

Assured by Use of New Electronic Gage

LARGE boom cranes that lift heavy sub-assemblies for warships have booms that extend over 100 feet and exert considerable leverage against

Safety margin in crane operation is indicated by this new instrument

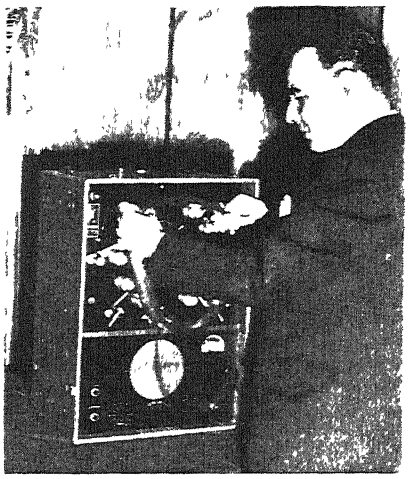
their mounts. The crane operator, perched in a cab 60 feet high, is constantly conscious of the danger of the crane overturning and must carefully adjust his controls.

To eliminate this danger, a crane stability gage, shown in the photograph, has been developed by electronic engineers of General Electric Company. The gage provides the operator with a continuous indication of the margin of safety and is arranged to stop the crane automatically if the boom is extended too far or is too heavily loaded

SOUND ON CELLOPHANE

Eight Hours Playing Time for a Single Table-Model Machine

SIXTY wiggly grooves on a 320-foot endless loop of inch-wide cellophane tape represent eight hours of recording for instant and automatic playback in a new portable cellophane-tape recorder developed by the Fonda Corporation.



Eight hours of continuous sound can be recorded on the cellophane loop being loaded in the recorder

Operating cost for recording tape is at present about 50 cents an hour to the consumer, with promises of substantial reduction when production goes up This figure is extremely low in comparison to other methods of permanent recording.

The problem of pressing a sound track on the tape, which is only about twice the thickness of ordinary cellophane, was solved by adoption of a yieldable felt bed directly under the recording needle. Both the recording and reproducing needles have permanent gem points that do not require changing and produce no shavings. The tape runs under the needle at a rate of about 40 feet a minute in standard models, and has room for 60 parallel grooves without risk of breaking into adjacent grooves. The action is entirely embossing and the pressed-out ridges can be felt at the back of the tape.

Simplicity of operation, low cost, permanence, and ability to identify any portion of a recording by marking directly on the tape with crayon make this an ideal reference recorder for the whole range of industry, from small offices to traffic-control towers at airports and the monitoring of radio broadcast programs. It can be connected to a radio set, program line, or directly to a microphone for recording every spoken word at a conference or interview No supervision is required during use—simply press one button to start recording, another to stop. Loading the preformed endless tape is simpler than threading a home movie projector.

Quality of reproduction depends upon tape speed. For voice reproduction 40 feet per minute is adequate; at 60 feet per minute the useful frequency response is extended to 6000 cycles per second, uniform within 2 db. The amplifier and loudspeaker are built right into the portable cabinet.

The standard model, for reference recording, requires attention only three times in a 24-hour day, for changing of tape. A stationary one- to eight-hour unit is available for such permanent applications as at airports, radio stations, and government uses, while a smaller unit recording for up to one hour has promising possibilities for office dictating uses.

Precision for Every Plant

Millionth-Inch Tolerances on the Production Line. Progress in Measurement Methods and Tools Has Been so Great That Even the Smallest Plant Can Afford the Equipment Necessary for Turning Out Products with an Accuracy Undreamed of in Manufacturing Processes of a Few Years Ago

ONLY TEN years ago, 300 leading manufacturers of machinery and machine parts were asked about the tolerances to which they were commonly manufacturing, and whether the trend of their tolerances was toward the coarser or the finer. A full 60 percent of them were working to the order of .001 inch as their finest tolerance, with limits for ordinary work in the .002 inch to .005 inch range; 38 percent had some production work that was held to .0001 inch limits, but such parts were rare; the remaining 2 percent were working to .00001 inch and were inclined to be boastful about it.

On the subject of the trend of limits there was almost complete agreement. All but two said that their tolerances were becoming finer and finer; would become still finer as fast as facilities could be accumulated for making them so. Only one man made any strong plea for coarser limits than the ones to which his plant was working, and it is interesting to note that his company got into financial difficulties twice during the depression although its competitors were making money.

The trend toward finer production limits accumulated force like a gathering tornado during the depression. It was destined to blow old-fashioned production methods off the map; make possible such devices as the synchro-mesh transmission and the Wright Cyclone aircraft engine—among thousands of others. On its further development depends the oncoming $2,500,000,000 market for frequency modulation radio sets (25,000,000 sets at a minimum of $100 each), the equally big market for television, the lighter but much stronger automobile, the family "flivver" airplane, and all the other devices which must be manufactured if people are to make their living after the war.

CLOSER TOLERANCES COMING—Only yesterday a limit of .00001 inch for production work was regarded with awe and was to be attempted only by men of the highest skill. Today, companies like Browne and Sharpe, Pratt and Whitney, L. S. Starrett, and George Scherr are turning out gages to measure to this tolerance as ordinarily as they might make gears or slide rules, and the crudest of labor can use these gages with very little training—the way such gages come flooding back to their makers for repairs shows that the labor using them is crude indeed. And in the very near future, tolerances of .000001 inch (yes, one millionth of an inch) will be out of the realm of the metallurgical laboratory or the tool room and into that of the ordinary production line. Many plants talk in millionth-inch terms right now, but the rarity of this fine tolerance is shown by the fact that, although square and flat gage blocks are among the simplest of millionth-inch-accuracy shapes to hold

Tests of surfaces with an optical flat show bands such as above if the surface is not true, but bands as below if it is practically flat

true, only eight factories in the United States are attempting to make them.

In spite of all that special machines and methods can do to control precision production, fine tolerances seldom can be held by workmen who do not understand the dignity and importance of what they are doing. So great is this problem that it might prove insoluble if it were not for the fact that fine tolerances attract fine workers. And since it takes high-grade managements to handle high-grade men, the effect of this situation upon management personnel is drastic. The tough talking, tobacco chewing foreman is gone with the cow-boy and the "Bull-o'-the-Woods" plant superintendent; in his place is the college trained man who depends upon superior technical ability to hold the respect of his men.

First step in the teaching sequence usually is to compare a fine dimension with the classical "fineness of a hair." Since the average human hair is .025 inch thick, it follows that 2500 tolerance areas of .00001 inch would have to stand on each others' heads to equal the thickness of a hair. This is something which impresses the new worker, and with which the old hand never ceases to impress his neighbors who pound typewriters or earn their living in other crass ways. It adds to his community social standing and to his pride in his job.

Second step is to demonstrate—and keep on demonstrating—the absolute cleanliness without which fine tolerance manufacturing is impossible. In terms of cleanliness this type of production yields nothing to any hospital technique, although the hospital pays more attention to antiseptics and the factory to temperature; the constant temperature rooms of more than one factory would compare favorably in cleanliness with many a hospital's operating room.

APPEAL TO HONESTY—In time the worker learns that any dirt around him, or dirtiness in his work, will show up as falsely finished parts or badly damaged instruments and machines. Add to this the appeal to his innate honesty—the fact that it is impossible for the fine-tolerance worker to conceal his mistakes and that only such men as do not attempt to cheat will continue to work beside him—and a man mentally gaited to fine limit production has been produced.

Close limit production would not progress very fast if it were inconvenient to achieve—if it could be had only in plants making large numbers of duplicate parts and having fat wallets with which to buy special equipment. On the contrary, it is largely because it is becoming more and more simple and convenient that precise production is coming along so rapidly.

The magnetic chuck for grinding machines and for light duty lathes and other machines, for example, was well known during World War I. But permanent magnets made of such materials as Alnico, strong enough to hold 30 times its own weight, are relatively recent developments. They can be used almost anywhere; they need no wiring up for current.

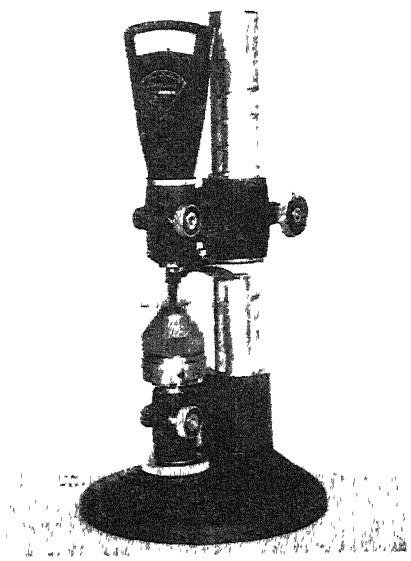
Convenient also are magnet blocks, consisting of alternate layers of brass or other high conducting metal and highly magnetic irons. Before these

came into general use, any magnetic chuck to be used for thin or especially accurate pieces had to be ground and trued up continually, a time-consuming operation which wore out the chuck with undue rapidity. But the magnet blocks can be placed on any magnetic chuck, and the blocks themselves ground or otherwise trued up. Often they are recessed or ground to special shapes. The holding power of the blocks is nearly equal to that of the chuck itself, while the wastage of time and of chucks is negligible.

Distortion of accurate parts and of the gages with which to measure them, once was a problem requiring time, patience, and money to solve. But distortion-resistant irons, largely based upon the researches of the International Nickel Company, are today quite common and inexpensive. And alloys like Invar, which changes dimensions less than one tenth as much as ordinary steels, under the influence of temperature changes, are available everywhere

LOWER COST—But perhaps the greatest factor in the convenience of accuracy, is the reduced price and the increased availability of the ordinary gage block

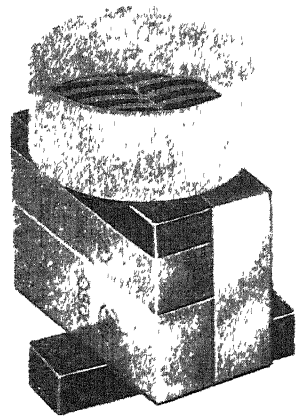
The gage block idea goes way back into the dawn of modern mechanical history Standard inches—they differ slightly in size—exist in Washington, D C., and in London, England. Both of them are based upon the standard meter which is—or was—a bar of platinum-iridium at the International Bureau of Weights and Measures in Sevres, France. (The original block's existence is no longer important, for a meter can be created in terms of light waves, being 1.553.155 72 wavelengths of the red radiation from cadmium, or 1.770,-039.01 wavelengths of the yellow-green radiation from krypton. or 1,993,738 86 wavelengths of the green radiation from helium at 20 degrees, Centigrade. 760mm barometric pressure. and 10mm vapor pressure.) But not very long ago any mechanic who wanted to have his gages checked had to send them to Washington for the National Bureau of Standards in order to have the work done



A radio quartz crystal, only .030 inch thick, being gaged between a flat spindle and spherical anvil

When Johanssen first started producing gage blocks in the United States, they cost $2000 for a small set. Such blocks were like jewelry The average mechanic knew about them and could discuss them on about the same basis that the average housewife knows about the goings on at the Stork Club But now sets of 81 blocks from which more than 120.000 combinations of dimensions in steps of 0001 inch can be made are available for less than $500; 34-block sets capable of 80,000 combinations cost less than $300; a nine-block set capable of 300 combinations is cheap enough so any mechanic who can afford good micrometers can afford the blocks to go with them

At such prices, gage blocks made to accuracies of a few millionths of an inch are put to hundreds of uses. A few· Check "go and no-go" or snap gages, check micrometers. set up sine bars accurately. set height or depth gages to

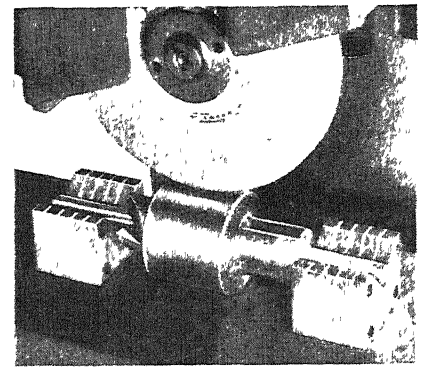


The light bands seen through the optical flat show the accuracy of the surface of the gage blocks

finest accuracy, set up machine tools. locate holes for jig drilling and boring, set depths of cuts on shapers or on milling machines, check the settings of positive stops on lathes.

Where a few years ago the average tool room man knew only by description that he should wipe the oil off gage blocks, rub them against the backs of his hands for a little lubricant, wring them together so that their edges meet exactly, wring them apart after using, clean and oil them before putting them away — he hoped some day to try this at a machinery show or somewhere — now such operations are daily routines in even the smallest of high-quality machine shops. And with them has come accuracy as a commonplace.

With the gage block has come the use of light waves for checking the flatness and the parallelism of surfaces. Not so long ago a mechanic who had just trued-up his micrometer would be likely to bring the spindle down to the anvil. hold it at eye level, and if he could not see daylight between the two parts, he would assume that spindle and anvil were square with each other and neither concave nor convex. Now he brings spindle and anvil against the faces of an optical flat — a piece of special glass



Magnet blocks make for accuracy

with its top and bottom planes lapped precisely parallel — and looks at the light bands which he can see through it If these bands are true, evenly spaced, and straight, then he knows his surfaces are flat and parallel. But if the bands are distorted, circular, or vary in color, then the surfaces are not parallel or are not flat—the colors and patterns of the bands tell the whole story. A second optical flat of slightly different thickness than the first is used for a second checking, for if the mike were tested at only one setting the anvil and spindle might be in true alinement at that position although at no other.

BETTER MIKES — Because micrometers can be checked so accurately and easily, a change has been made in the thinking about them. Once it was considered that, although any mechanic might measure to .001 inch with a micrometer, only an expert could be sure at .0001 inch — a false sense of touch or "feel" would throw the less trained man off Many micrometers then did not even have the ten thousandth of an inch vernier scale on them. But now it is believed that a reasonably trained man can measure to a ten thousandth if the mike is right. Many authorities consider the micrometer which will not measure to a ten thousandth to be obsolete in any size less than three inch (Above three-inch the heat of the hand will itself throw the tool off more than a ten thousandth unless it is handled by a man skilled enough to avoid this.)

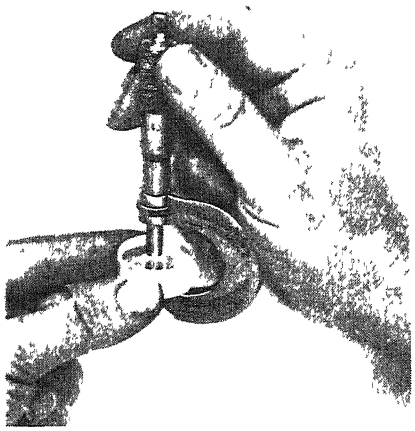
Such trust in accuracy is important. For micrometers are still the most needed tools for fine measurements — they are the infantry of accuracy.

Rapidly developing, also, are the instruments which throw shadows of parts to be measured upon ground glass or other screens. Wherever contour is to be gaged, these are making rapid strides.

One of their great advantages is that a permanent record can be made of the story they tell. With a piece of paper laid across the screen, the silhouette made by any coutour may be traced with a pencil. In some cases a photographic film is laid on the screen and direct exposure made. Such records show exactly what is wrong with a production machine set-up and thus cut down the highly expensive set-up time, or show how rapidly cutting tools are wearing and thus give warning of the need for sharpening and replacing them, and the like.

Shadow instruments, with others, also

are being used to speed the developments of new products. Everyone knows that two boats — or two automobile engines—may be made as nearly alike as human ingenuity can contrive, and yet one may run much better than the other In modern experimental departments the superior product is taken apart and every dimension and contour on it is traced on the shadow screen, in-



Checking a mike optically

terior surfaces being followed by mirrors. The same treatment is given the inferior product, and all contours carefully compared. In case after case, this method discloses the secret of superior performance — a secret that "trial and error" might need years to find.

The onward rush of accuracy is in materials, men, and instruments. Except for one point, no one knows exactly what the post-war product of any machine shop will be like. That one point is: It will be made to tolerances little dreamed of in the pre-war days

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FOREMEN

Are Being Recognized as Most Important in Factory

No matter what anyone may think of foremen joining labor unions and thus calling themselves part of the labor force instead of representatives of management, when organized foremen pulled strikes in middle western plants recently the value of foremanship was proved as never before. Production decreased to the vanishing point.

One quick and direct result of this realization was the setting up of dozens of plans for giving special incentives to foremen. Forward-looking companies like Caterpillar Tractor and Lincoln Electric had done this years ago. Now the practice promises to become as wide as all industry.

A drop-forging shop in New Jersey intends to give forge room foreman bonuses based upon the metallurgical results in the parts which come from their hammers. A plastics shop will pay foremen extra wages if absenteeism and labor turn over is low in their departments. A cotton mill will tuck a little extra into the foreman's pay envelope if the call for repair parts to the machines under his control goes down And a printing press manufacturer gives rewards if the spoilage of parts is less while production speed stays up

These and other plans show that the foreman is being recognized for what he is—the most important man in the factory

CLEAN PLANTS

Make Possible Precision Production

The spotless house-keeping of modern factories is one of the miracle producers of this war It makes the modern accuracies practical, is one of the factors without which they would be impossible.

It takes an old timer who is thoroughly familiar with old style methods to appreciate just how far this cleanliness goes Many a youngster, just cutting his industrial teeth, does not realize the extent to which dirt once was taken for granted.

A flight control instrument is taken apart at the plant of the Minneapolis Honeywell Regulator Company. As casually as if they were in their own homes or clubs, executives lean their light-colored coat sleeves on benches and a Navy man takes the instrument apart without bothering to cover up his uniform There is no excess oil about, no grime.

A white smocked inspector leans over a telescope through which he is checking the calibration of an anti-aircraft gun sight aimed at a fixed target. The slightest dirt would show up on that smock and be a warning that the clean-up gangs had better get busy and the operators be more careful.

Dressed in light colors, a spray-gun operator performs what used to be one of the most soiling tasks in the plant. Spray painting is done right in the middle of production lines now; it used to be relegated to special rooms where its fumes and splashings could not do damage to other operations Evacuation from the cabinet, size and shape of the spray stream, and pressure

No excess oil . . . no grime

The smock serves as a dirt tell-tale

of application, are so well controlled that the operator will leave his shift as clean as he came on it.

Perhaps the best demonstration is an operation like the grinding and polishing of the insides of glass tubes. Here the operator wears oil-proof gloves; she must apply extremely fine rouge with a paint brush to moving parts, and it will get on her hands. Her smock will get a little dirty too where she rests an idle hand against it. But there is no soil on the front of her; her bare arms and face are not spattered, for the operation is too cleanly controlled for spattering.

Millions of operators trained to the cleanliness of modern plants will go home desiring clean machinery that is easy to keep clean, and this inculcated taste will be one of the big factors in the post-war markets of American industry

SPECIAL MICROMETER

Used to Determine Hardness Of Plastic Stock

The screw-thread principle of the micrometer is being applied in dozens of special ways, many of which are based upon modifications of standard micrometers.

One type of plastic, for example, is extruded into round bars and then put aside for seasoning. On the stock shelves it shrinks somewhat, and also acquires varying degrees of hardness. Extents of both changes vary with different lots of material from the mixing machines, and even differ in the same batch.

Formerly it was the practice for the fabricating room supervisor to find by trial and error exactly how to "work" any lot. Now a micrometer is used having a pointed spindle and a tiny spring scale on the anvil The spindle is advanced to the rod to be measured and the outside diameter found in the regular way. Then the foreman or machine set-up man who is using the instrument advances the spindle so that its point penetrates the stock, at the same time watching until the scale pointer comes to a predetermined mark. The penetration of the point into the material is a measure of the hardness of the stock and a guide to the setting of the tools for most rapid and successful machining.

X Marks the Spot

An Advance Account of the New Hillier Electron Microanalyzer Now Undergoing Development at the RCA Laboratories. Related to the Electron Microscope, It Serves a Different End, the Elemental Analysis of Minute Samples of Matter. Will it be Applicable to Industrial Laboratory Investigations?

By ALBERT G. INGALLS

RECENTLY, in a short communication to *Physical Review*, journal of American professional physicists, Dr. James Hillier of RCA Laboratories announced the preliminary development of a new fundamental tool to which he gave the name electron microanalyzer. Its function, he said, was the elemental analysis of extremely small areas within electron microscope specimens

While the familiar chemical analysis can deal with specimens or samples that are small or even almost microscopic, and the spectrograph can give elemental analysis of still smaller specimens, the new Hillier instrument will go much further. With it the user can select from a specimen already so microscopic that it must be magnified thousands of times in order that its details may be seen at all, one local area or perhaps a particle no larger than 1/100,000 inch in diameter and as small in weight as 1/1,000,000,000,000,000 gram, and determine exactly which chemical elements that one single sub-microscopic area or particle contains. An instrument which can accomplish so remarkable a feat must be highly specialized and, in fact, superspecialized.

Just what this new tool will one day accomplish not even the wisest can now say, since there is no reliable way to predict the future of a baby In the belief, however, that so specialized and powerful an instrument may prove ultimately to be one of the important working tools of science I went to the fine new RCA Laboratories, near Princeton, New Jersey, saw Dr Hillier and used his electron microanalyzer.

Dr. Jim Hillier is not the "typical" scientist of fiction and the daily press: he looks and acts like an average human being. However, since the typical scientist of our day does look and act like an average human being, the "typical" scientist of ancient tradition being either imaginary or extinct, paradoxically Dr Hillier is therefore a typical scientist. He is Canadian-born, now nearly U. S.-naturalized, and is 28 years old, a graduate of the University of Toronto where he specialized in mathematical physics.

If you look even a little into the technical literature of the electron microscope, of which Hillier's new electron microanalyzer is a relative, you find something like the following: German physicists developed the first crude electron microscopes about a dozen years ago; the first in the Western Hemisphere were built at the University of Toronto half a dozen years ago by Hillier and Prebus and were not crude: and Hillier came to RCA Laboratories four years ago and there, with A. W. Vance and under the direction of Dr. V. K. Zworykin, designed and developed a type of electron microscope that is adapted to practical industrial research. You also learn that more than 50 of these standard instruments are already in the laboratories, mainly of large industries and scientific institutions. Thus, Hillier is one of a rather small number of principals who have given science the electron microscope; also of a much smaller number who have made a practical working model actually available to industry.

HOW IT WORKS—Dr. Hillier, with Dr. Zworykin and Hillier's new and partly developed electron microanalyzer, the only working model yet in existence, are shown in Figure 1 This instrument is at present far from its production stage—some distance, in fact, from the end of its laboratory stage of development. How it functions may be told, skipping less essential details, in four stages.

First, the electron microscope, which is a built-in accessory of the electron microanalyzer, shoots electrons through a given specimen, in the ordinary manner of an electron microscope, and the highly magnified image thus produced is spread out on a fluorescent screen and studied visually.

Next, when and if some small local area, perhaps a particle, in this highly magnified image arouses the curiosity or suspicion of the user, the whole image is adjusted sidewise and endwise by means of mechanical control mechanisms until that area or particle is brought precisely under fixed crosshairs on the viewing screen.

Third, with this local area now put literally on the spot, a rheostat knob is turned and this refocuses and concentrates all the electrons that previously gave the broad field of vision into a single, narrow probe. The electrons now pass through that one area and no other.

Finally, these electrons, after passing into the atoms of the different chemical elements in the tiny area of the specimen selected for analysis, emerge from these atoms at *different rates of speed*

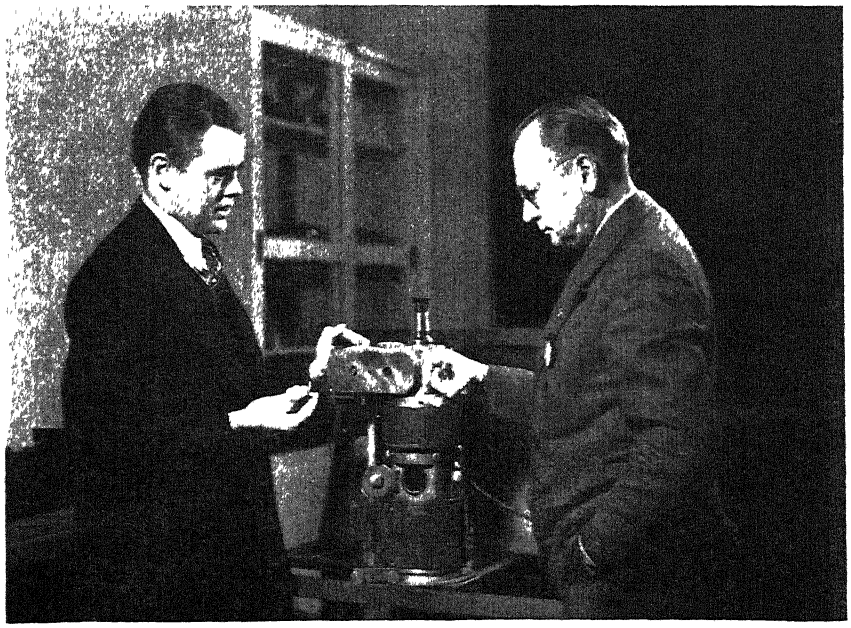


Figure 1: Dr. James Hillier (left), electron microanalyzer, Dr. V. K. Zworykin

for each element and are made to leave a visual record of these speeds on a photographic plate. This record permits identification of the elements in the area.

Figure 3 shows how these four steps are performed, and this calls for a short review of the electron microscope itself, described in Scientific American, July 1940, from which Figure 2 is reproduced. The two drawings show the close analogy of an electron microscope with the ordinary optical or light microscope

In the light microscope the waves coming from a light-source are made plane by a lens L_1; the object to be examined is placed at AB; the lens L_2 bends the light that passes through it and forms a magnified image at $A'B'$ Then the next lens L_3 takes waves from a small piece of the image already magnified and bends them again, forming a once-more magnified image at $C'D'$.

INTERESTING DIFFERENCES—In the electron microscope almost the same thing happens, though under different auspices. Electrons which are accompanied or guided by waves as is now known, are shot off by the anode and fly away in streams of billions at velocities perhaps half that of light. Those that pass through the first magnetic lens L_1 are bent and made parallel. The object under examination is placed at AB. The second magnetic lens L_2 bends and magnifies, giving image $A'B'$, a small piece of which is again bent and magnified to $C'D'$. The analogy in basic working principle is almost complete but there are several interesting differences in method.

The first is that, while in the light microscope pieces of glass (lenses) shaped so that they will reduce the velocity of the light just the right amounts in the right places to accomplish their purpose are employed for bending the wave-fronts in order to form an image and bring about magnification, in the electron microscope the analogous bending is done by open-centered magnetic solenoid coils through which the electrons pass. Physicists also call these "lenses" because they accomplish the same purpose as lenses of glass, that is, bending or refraction; but the actual bending is of course done by the intangible magnetic field of force which they cause. Glass lenses would not suffice for the same purpose in the electron microscope because the glass would completely stop the electrons.

A second difference is that, while the waves used in the light microscope and received on the screen or retina within our eyes are perceived by this visual screen direct, the electron waves used by the electron microscope are far too short to be thus perceived, being only about 1/100,000 as long. They therefore have to be correspondingly lengthened. The zinc sulfide or other fluorescent substance on the fluorescent screen of the electron microscope has the power to take in short waves and lengthen them to visible length and send them out again. They come to this screen in such vast numbers and in such a fine pattern that they reproduce on the screen the original pattern of the otherwise invisible electron waves. That, then, is how we see with electrons —indirectly.

A third difference is that, while waves of visible light quite easily pass through the solid glass lenses and the air between them, the large air molecules, if permitted to remain in the electron microscope, would block the electrons

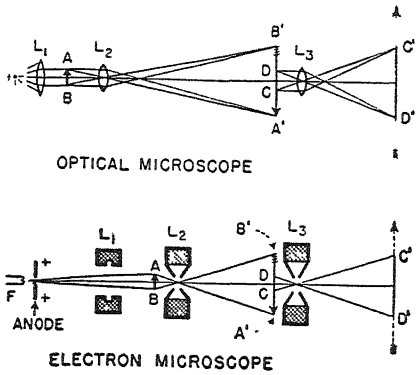


Figure 2: The analogy of two kinds of microscopes. Described in text

as easily as a bank of big boulders would block a swarm of small bullets. Hence, about 9,999,999/10,000,000 of these air molecules must be pushed and bumped out of the interior of the electron microscope by means of mechanical and diffusion pumps, and kept out, before that instrument can function.

A fourth difference is that, while the glass slides used for mounting specimens for the light microscope do not appreciably cut off the light, nor does the specimen itself in many instances, in the electron microscope the glass slide would stop all the electrons and so would the specimen unless it were very thin. Therefore, the specimen is mounted on a film of collodion only about 1/2,000,000 inch thick. The technique of mounting is, however, simple and requires but a few minutes. If the specimen itself is thicker than a minimum the electrons must be shot at it with greater speed in order to penetrate it.

A fifth difference—one that favors the electron microscope—is the flexibility of its lenses. Simply by turning rheostat knobs the magnetic fields in the magnetic lenses may be varied in strength by infinitely adjustable degrees. Only a "glass lens of rubber" could permit this amount of flexibility. However, because the magnetic lenses of the electron microscope seem so flexible and are intangible, there often is a temptation to assume that the standards of refinement of design and construction in one may be equally flexible and vague. This is far from true, since any but high tolerances in the mechanical construction of the critical components would ruin the functioning of the instrument. Similarly, the electron velocity and focal lengths of the magnetic lenses must be maintained uniform within one part in 20,000, else the instrument will not stay in focus.

So much for the electron microscope itself.

THE INITIAL SEARCH—Even a brief comparison between the electron microscope diagrammed in Figure 2 and the electron microanalyzer diagrammed in Figure 3 reveals that the Hillier electron microanalyzer includes an electron microscope. The same three magnetic lenses appear in each instrument. The envelopes of the spreading beams of electrons, as in Figure 2, are shown by short, incompleted but similarly spreading lines in Figure 3. This is the form they take when the user is examining the specimen in the initial search for some detail or particle in it to analyze. Through the magnifying eyepiece he sees the image on the fluorescent screen shown at the top in Figure 1.

Suppose that you are yourself the user of this electron microanalyzer and are doing medical research on the germ of a disease. For years you have been familiar with its rod-shaped bacilli as you frequently examined them with the light microscope at 1000 diameters' magnification or by photomicrography under the ultra-violet microscope's top-working, practicable magnification of 3000. In that kind of bacillus you were always able to make out, or resolve, some details — just enough to tantalize. Yet you knew that if you could see and study the full, actual details you might come to understand more about the functioning of that bacillus and perhaps, through that, find a new approach for attack on the disease it causes. Now the electron microscope becomes available and your enterprising organization obtains one. At one jump your top magnification rises from 1000 to 3000 diameters to 100,000 diameters and, since the observation of disease germs has been your lifelong career, you naturally become a bit excited and stirred by what you see. You discover that your bacillus assuredly has a considerable variety of details, as you had suspected, and is not just a lump. The whiplike appendages you had seen faintly with the light microscope are now found to have a much greater length than you or anybody had known. They also are more numerous.

Inside the transparent body of this little bacillus, itself only 1/10,000 inch long, you notice interesting granules, very tiny, which you did not even know existed, and as you gaze at them you mutter, "Never saw those before. Wonder if they aren't possibly the protein concentrated in one place in this granular form." The electron microscope in itself cannot answer that question. Even with it you cannot analyze a granule merely by looking at it. You could, of course, perform a number of chemical tests on the bacillus until you found a reaction that would give you some knowledge of the chemical structure of the granule, but you would have to do this by looking at the granule in the electron microscope, taking it out and treating it with a test chemical, returning it, finding the same granule and checking to see whether there now was any difference. This would be very tedious and not too often successful.

AND IT ALONE—So with the electron microscope you can look at this granule in one end of one bacillus, but with the

electron microanalyzer you also can analyze it! It and not the remainder of the germ. It alone. And in this fashion

You manipulate the specimen until the bacillus and then its granule is in exact position under the cross-hairs. Then, with the rheostat knobs that alter the strength of the magnetic field you re-focus the instrument drastically. The formerly diverging lines of electrons that gave a broad-field view are made to converge. At the same time the image of the granule itself grows in size It expands about its own central point and eventually it—the image of that one single granule alone—covers the whole fluorescent screen. Now the electrons are moving in the paths enveloped by the full-length lines of Figure 3 The tip of the electron needle, so extraordinarily fine that it is no bigger at the point than the particle to be analyzed, is just touching the granule in the specimen (which, by the way, in the "silhouette," or "shadow," type of instrument used in the electron microanalyzer is placed two stages nearer the top than in the standard type). Now the electrons are all passing through that granule and no other part of the general specimen or even of the bacillus. Their velocity has been stabilized so that they all have exactly the same speed.

Next, the velocity analyzer is switched on This consists of a large electro-magnet, its oblong coil showing in Figure 1 just in front of Dr. Hillier's left hand. This magnet applies a homogeneous magnetic field to the gap through which the electrons travel, and this uniform magnetic field deflects each speeding electron in proportion to its velocity Thus, the slowest electrons are able to make the shortest U-turns, faster ones make larger U-turns, while the speediest go farthest out and around

After traversing its U-turn, each electron in this "half-circle type of velocity analyzer," as physicists term this particular type of apparatus, strikes a photographic plate and wherever this is struck it is exposed. When the plate is developed it is seen to bear markings, of which those sketched under it in Figure 3 are characteristic. In this sketch of an "electron velocity distribution" the hits are seen to be bunched or concentrated at certain distances from the edge of the plate. Actually, because there is some unavoidable electron scattering, the electrons fall to some extent all over the plate, but a smooth curve of their frequency, of which the one also sketched in on Figure 3 is typical, reveals that most of them strike at or near certain significant distances measured from the edge of the plate. *Each distance corresponds to a different chemical element.* And there is your analysis.

In another instance you have in your hand a test tube in which are a number of mixed chemicals. Suppose you have put a tiny sample of this mixture in the electron microscope and examined it. Yes, there are some particles, several types of them, and these types undoubtedly make up some of the chemicals that were in the test tube but which are which? This you cannot tell. Merely by looking at them you cannot distinguish which particle is one chemical and which is another. This, on the other hand, is one of the kind of things the electron microanalyzer should be able to tell you direct and quickly.

Just exactly why the electrons, after passing into atoms of different chemical elements at uniform speed, emerge at different speeds, is a question you may have been asking. It has been explained thus: "On the basis of the physical knowledge already in existence, we can visualize the atoms of the target as being heavy nuclei surrounded by a number of electrons These electrons arrange themselves into what are often called shells. As we go through the table of chemical elements we find that the most noticeable difference from one element to the next in

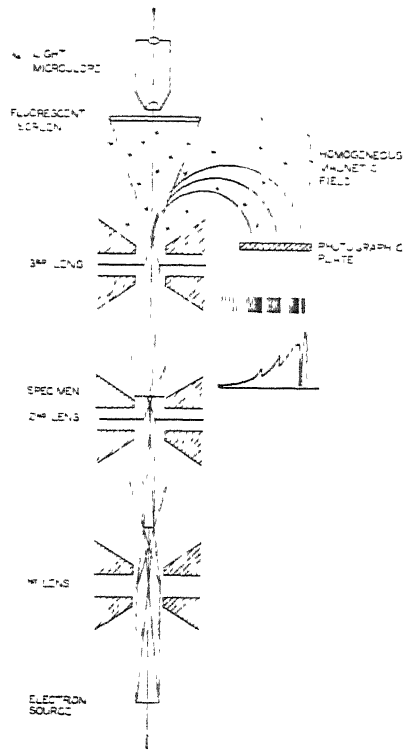


Figure 3: An elevation diagram of the electron microanalyzer. See text

the structure of the corresponding atom is the addition of an electron to the outside shell, the addition of a unit of positive charge to the nucleus, and the addition of more mass to the nucleus. Thus, the innermost part of the atoms of different elements is very similar, consisting of the nucleus, two electrons swinging around what is known as the K-shell, eight slightly farther away in the L-shell, and so on, until in the heaviest atom you have 92 electrons all told. It takes a certain amount of energy to knock an electron out of an atom and the closer that electron is to the nucleus—the nearer to the K-shell—the more energy it takes, and the energy is taken from the original incident electron. In other words, as a result of the collision, the fast-traveling electron will continue on its way but will have been slowed up a little. This is what leads directly to the experimental arrangement in the electron microanalyzer. If the specimen is thin enough and the electrons are going fast enough they will not collide with more than one or two atoms in it." For greater penetration electron microscopes employing higher voltages to speed the electrons faster may be used. RCA has one working at 300,000 volts.

Thus far, Dr. Hillier has calibrated his electron microanalyzer for only a part of the elements—those most important in biology, such as carbon, hydrogen, oxygen, nitrogen, calcium, and potassium Work on the others proceeds He has not yet reduced the instrument to a basis of quantitative analysis—it is still qualitative in nature—but that may follow. It is not, however, anticipated that it will ever be able to do the analyses of chemical compounds. That is, it might tell us that a given particle contained, for example, hydrogen, carbon, oxygen, and nitrogen, and perhaps later how much of each; but it can scarcely be hoped that it can even tell us how these atoms are combined into chemical compounds. There are, however, many circumstances under which experienced chemists can make shrewd and helpful guesses.

INDUSTRIAL POSSIBILITIES—Could not this instrument, when fully developed, find many practical applications other than the biological, with which its initial experimental trials have been made? May it not, with its special "micro-micro" power of analyzing single submicroscopic particles, prove to have even greater uses in the laboratories of the industries, possibly for the precise study of microscopic impurities in commercial products?

The development of the electron microscope belongs to a number of scientific men but the electron microanalyzer is Hillier's. He brilliantly combined several parts and principles previously known to physicists (some of which he also further developed) with the use of the electron probe to increase the precision of the electron velocity analyzer. In fact, it is the double use of the electron probe in one instrument that makes the electron microanalyzer the highly specialized instrument that it is. In other words, no probe, no microanalyzer.

In answer to direct questions Hillier says the whole idea, with the several organized essential parts and principles, working together to one end, popped into his head one day without conscious cerebration. Inventors speak of this type of discovery as "flash of genius." This is sometimes mistaken to mean that no real work has been done and that, simply, an angel flew down, handed the favored recipient a finished blueprint, smiled, and flew away. Actually, it usually means, as it did in this instance, that much conscious cerebration has previously been done in and around the subject, and for most of us cerebration is work, a form of suffering. Even when the "angel" has imparted the bright idea the sufferer's troubles have only just begun; for he isn't yet half-way to first base. With the still infant electron microanalyzer Hillier is now leaving third base for his home run. I found him at work on it in his laboratory in his shirtsleeves.

Jet-Propulsion Flight

The New Jet-Propelled Plane Flies Fast and is Safe. An Analysis Reveals its Superiorities and Inferiorities and Points Out its Possible Future. The Struggle of its Oft-Frustrated Inventor and His Final Success Affords a Romantic Story of a Young Man's Determination

LAST month's article reviewed the aviation engine of today, thoroughly modern, constantly improving and growing in power and efficiency, but still of conventional design and well-tried principles. Now the dramatic announcement of the Bell Interceptor fighter, powered with an engine of the so-called rocket type, makes it timely to discuss this radically new power plant.

Since press and public alike speak indiscriminately of rocket and jet-propulsion engines, a definition or two may be helpful.

In both types the propeller has gone. In both, combustion or detonation is made to occur in a chamber and the gases, which are the products of the combustion, make their exit toward the rear through orifice or nozzle, at high temperatures and high speeds.

NEWTON'S LAW—Pressure inside the chamber drives the gases out. On Newton's law, that action and reaction are equal and opposite, a thrust is exercised on the combustion chamber or engine, and hence on the airplane or other vehicle (Figure 1).

While the above description applies equally well to rocket and jet-reaction engines, in the rocket a mixture of fuels contains within itself the oxygen necessary for combustion; in the jet-reaction engine, the fuel is carried in the vehicle but oxygen is fed by air from the outer atmosphere.

Important as the rocket may be in the exploration of the upper atmosphere or ultimately as a method of interplanetary travel, in aviation the jet-reaction engine is the greatest concern.

The new Bell plane, equipped with two jet engines, flies between 500 and 600 miles an hour (nearly 100 miles an hour faster than any other type of aircraft). The engine has been built by General Electric, the plane by Bell Aircraft Corporation. Instead of expensive, highly volatile, high octane gasoline, the engine can employ kerosene or almost any variety of liquid fuel. The chief immediate application of the engine will be in interceptor fighters or high-altitude reconnaissance aircraft—the fuel consumption per horsepower hour is far too great for the engine to be used in bombers or any craft, for that matter, in which sustained operation may be required. It might conceivably be installed in existing heavy bombers, however, to obtain "flash performance," to help big planes to get off with heavier loads or to give them a burst of speed in getting away from attackers.

According to Brigadier General B. W Chidlaw, Chief of the Materiel Division of the Army Air Forces, our pilots will find no trouble in operating the new aircraft. There are, according to General Chidlaw, two distinct sensations in flying the jet propelled aircraft—lack o noise and lack of vibration. The plane is neither noiseless nor does it fly with the speed of sound, but the elimination of the propellers and the fact that the noise from propulsion is to the rear makes for quietness in the cockpit and reduces pilot fatigue.

The absence of vibration should have several advantages, including ease of handling, particularly in fight maneuvers, and in reducing wear on structure and instruments. To those below, the new plane in flight sounds like a tremendous tea kettle at full boil; persons in an English district where its experimental flights have been made, have nicknamed it the "squirt." It is an awe-inspiring sight to see the aircraft become visible on the horizon, pass in view for a few seconds, and vanish specklike on the opposite horizon. That the new planes are likely to be safe in piloting as well as highly effective is attested by the fact that several hundred successful flights have been carried out by American pilots in the United States and British pilots in England without a single mishap.

The development of the jet-propulsion engine illustrates once more the wonderful co-operation which exists between the American A.A.F. and the

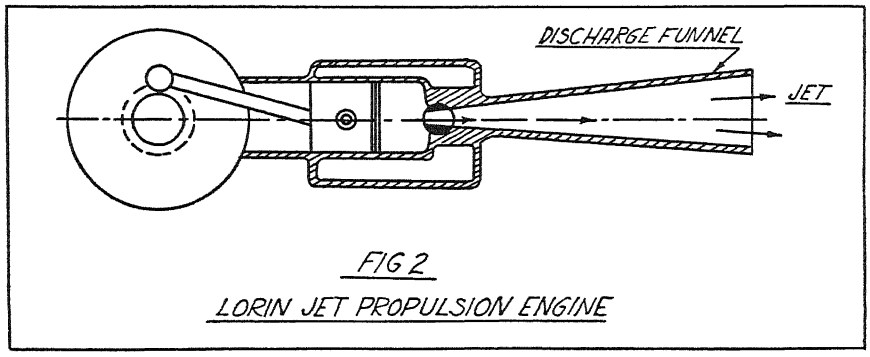


FIG 2
LORIN JET PROPULSION ENGINE

An impractical scheme

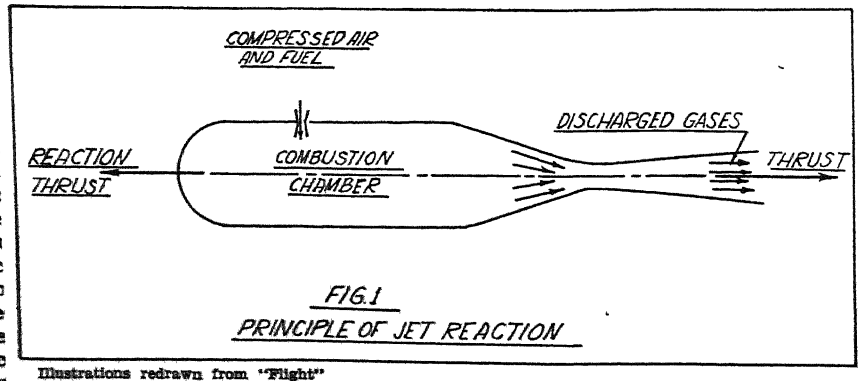


FIG.1
PRINCIPLE OF JET REACTION

Illustrations redrawn from "Flight"

How thrust is exercised

British R.A.F. The British Air Ministry placed its first order for an aircraft using a jet-propulsion engine in 1939 with the Gloucester Aircraft Company, and engines and aircraft were ready May 1941, but the United States was fully informed well before our entry in the war, namely in July 1941. Ever since then the A.A.F. and the British Ministry of Aircraft Production have been in constant co-operation and have exchanged all information obtained.

There are two types of efficiency to be considered in an aircraft engine—thermodynamic or internal efficiency, and propulsive or external efficiency.

The thermodynamic or internal efficiency of an internal-combustion engine—the ratio of the power developed to the thermal energy contained in the fuel—is quite low. The number and character of the losses is ominous Thus there are chemical losses owing to incomplete combustion, bad mixing of gases, loss of fuel through exhaust. Then there are cooling losses through the walls, losses through pistons and valves and in inlet system and carburetion. Mechanical losses amount to 15 percent, exhaust losses to 30 percent, and the overall internal efficiency amounts to only 30 percent or thereabouts.

COMPLETE COMBUSTION—In the jet-propulsion engine, the picture is quite different. Combustion can be complete and, since there is no piston to seize up, there is no necessity for cooling losses and chambers could even be lined with refractory materials. The chemical losses are eliminated and, with a long exit nozzle, it is possible to go a long way toward converting heat energy into kinetic energy, so that exhaust losses are reduced to a minimum. Some well-informed German writers have estimated internal efficiency to be as high as 70 percent, and Professor Goddard's experiments indicate internal efficiencies of the order of 50 percent.

But when external or propulsive efficiency is considered, conditions are completely reversed. The modern airplane propeller is highly efficient and, in its best form, with controllable pitch, its efficiency may be as high as 85 percent. In the jet-reaction engine the propulsive efficiency is very low. The gases leave the combustion chamber at high velocity, say 6000 feet per second and produce a thrust, T, by reaction Suppose the airplane is itself moving at 600 feet per second. Then the work done on the airplane is (T x 600); the work done on the gases is (T x 6000). The efficiency is the one divided by the other—only 10 percent.

In this only approximately correct exposition can be seen the main difficulty of the jet-reaction principle. The gases come out too fast and carry away too great a proportion of the energy of combustion.

What are the possible remedies? First, very great speeds of the airplane itself, which means flight at high altitudes; second, some way must be found of mixing great quantities of air with the jet. The mixture of burned gases and air would then leave the jet-reaction engine at very much lower speeds and the external efficiency would be very much greater.

Examining the history of the art it will be found that many different proposals and inventions have been made, dating back many years. In fact, there have been so many of these proposals that anything like a comprehensive review is impossible in this article. One of the best sources of information is a series of brilliant articles by G. Geoffrey Smith in *Flight* (London). While we do not always share Mr. Smith's views, we have found his splendid summary of the early art tremendously helpful.

Perhaps the simplest illustration of a jet-propulsion engine is that shown in Figure 2, a scheme devised by the French engineer Lorin. Monsieur Lorin imagined that he could take a simple internal combustion engine of the reciprocating type, charge, compress, expand, and exhaust the gases in the usual fashion but, instead of the engine driving the propeller, the gases were to be made to pass through a reaction jet. While this simple scheme illustrates principles in a graphic manner, it cannot be considered at all practical. Monsieur Lorin's scheme combines all the difficulties and losses of an internal-combustion engine with the propulsive or external inefficiency of the jet-reaction engine.

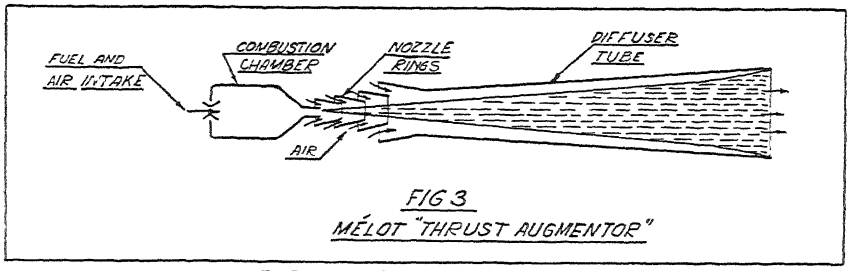


FIG 3
MÉLOT "THRUST AUGMENTOR"

A distinct advance in jet reaction

FRENCH CONTRIBUTIONS—Lorin is but one of many French inventors in this field. The French have apparently the national characteristic of taking up new ideas in brilliant fashion ahead of anyone else but are not so likely to carry through to the end. They did, however, contribute wonderfully to the basics of jet-propulsion flight. Thus the Melot thrust augmentor, as illustrated in Figure 3, was a distinct advance. The principle is that, as the gases leave the combustion chamber in a rearward direction, additional air is sucked through a series of nozzles of increasing diameter into a diffuser tube. As a result, the thrust is augmented by an additional mass of air. This device, subsequently tested by engineers of the National Advisory Committee for Aeronautics, did indeed increase the thrust, perhaps as much as 37 percent over the theoretical thrust of the free jet. Of course, this is still far from removing the propulsive inefficiency of jet reaction but it does show that augmentation is a useful idea.

Other devices have been proposed by the Junkers Corporation of Germany, by Dr. Eichelberg of Zürich, Switzerland, and by a number of British workers besides Captain Whittle.

As far as is known, the only jet-propelled plane which has actually flown prior to the Whittle design is the Caproni-Campini machine, which, on November 30, 1941, made a flight from Milan to Rome at an average speed of 130 miles an hour, which is low for a machine of this type.

A purely diagrammatic representation of the Campini design is shown in Figure 4. Air is admitted between the cabin A and the enshrouding cylinder. A radial internal-combustion engine drives a two-stage centrifugal compressor C. Beyond the compressor, the air

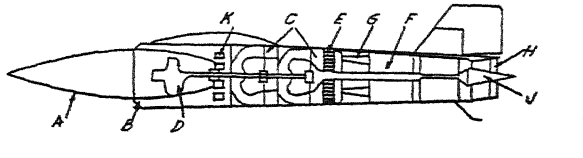


FIG 4
CAMPINI DESIGN

The first jet-propelled plane to be flown used a power plant of this type. Parts are explained in the text

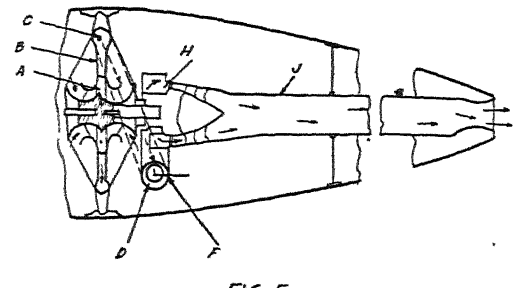


FIG 5
WHITTLE PROPULSION PLANT

Right: Basic elements of the Whittle conception of a simple jet engine, incorporating an effective gas turbine

passes through a radiator, which also acts as a rectifier, into a large combustion chamber *F*. An annular mixing channel *G* supplies vaporized fuel into the combustion chamber After combustion and expansion, the gases discharge at the rear through a discharge nozzle *H*. The nozzle orifice can be varied by cone *J*.

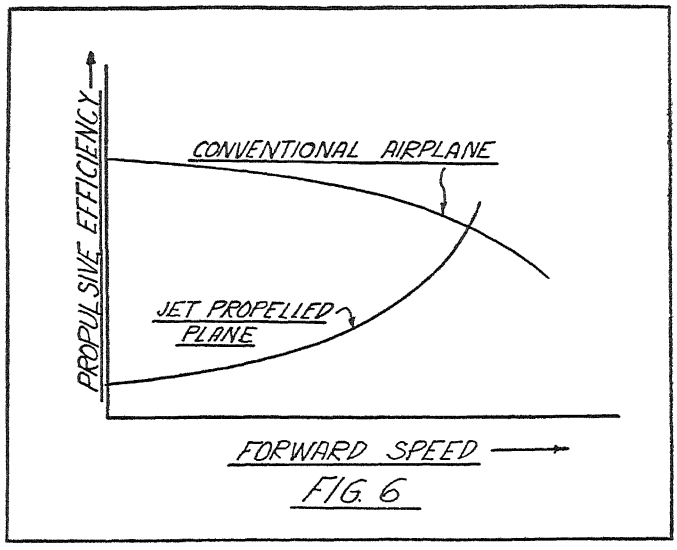
The Campini design was not very efficient but it did comprise the essential elements and principles of the jet-reaction engine and plane, such as a combustion chamber to which fuel is suitably applied and a compressor so that a far greater weight of air passes out through the rear nozzle than the weight of fuel actually burned. But it certainly adds to complexity to have a reciprocating internal-combustion engine, and the thermal efficiency of an internal-combstion engine is none too high. The Campini power plant is both heavy and complicated and takes up the entire space of the fuselage, which is a drawback. Moreover, no attempt was made to recuperate energy from the internal-combustion engine exhaust.

Captain Whittle has advanced a number of plans for his jet engines. Figure 5 shows the basic elements of one of his conceptions: *A* is a compressor impeller. *B* is a primary diffuser chamber; *C* is an air delivery scroll. The compressed air is delivered to the helical combustion chamber, *D*, where it is combined with fuel by fuel injector, *F*. The products of combustion then drive the turbine rotor, *H*. The turbine itself drives the compressor impeller, and the products of combustion, after passing through the turbine, are drawn rearward to provide jet reaction.

In basic principle there was little difference between Whittle and Campini The Whittle design has the advantage that a very simple and effective gas turbine is substituted for an internal-combustion engine. The simplicity of the design is marked. Captain Whittle has advanced other plans, but military secrecy does not permit description of the exact plans employed

In principle, the jet propulsion of aircraft has been solved. How soon and under what conditions will it become a serious competitor with the conventional reciprocating engines and screw propeller? Up to limited altitudes, the conventional aircraft power plant provided with a suitable supercharger remains surprisingly efficient. Even at as great altitudes as 40,000 feet and with the aid of gear-driven or turbine-driven superchargers, the power of the engine may be substantially maintained and the efficiency of the propeller can remain very high. But at very great altitudes, the air becomes so thin that it is exceedingly difficult to maintain the power of the engine. The supercharger itself now absorbs so much power that the net output of the engine is seriously diminished. At the same time, owing to the low density of the atmosphere at great altitudes, the propeller, in spite of variable or controllable pitch, becomes increasingly incapable of absorbing the engine power and also loses in efficiency. Thus the efficiency of the conventional aircraft power plant, stationary up to a certain altitude, thereafter begins to drop off rather rapidly.

On the other hand, the jet power plant is very inefficient at sea level at relatively low speeds. At very high speeds and in thin air, the expansion through the nozzle is facilitated and the internal or thermal efficiency of the engine remains stationary or drops off but little Further, since at great altitudes the speed of the airplane increases, the external propulsive efficiency of the jet engine increases to a marked degree.



Efficiency curves for two types of aircraft propulsion

FUTURE OF THE JET—The dropping off in efficiency of the conventional power plant and the increase in efficiency of the new power plant is diagrammatically illustrated in Figure 6 Perhaps a point has been reached where the two curves cross, but if not, it will be reached very quickly, and at that time the jet engine will come into its own

An aspect of the jet-reaction engine which may be applied on a wide scale quite shortly is in the problem of assisted take-off As heavy bombers and trans-oceanic aircraft fly greater and greater distances, they burn more and more fuel, and as a result the bomb-load or pay-load falls off appreciably. If a jet or rocket engine is employed for just a few seconds, or half a minute at the most, it is possible to make a take-off with a far greater gross weight The larger gross weight, in turn, has a very marked effect on bomb- or pay-load. For trans-oceanic travel of the future, it is quite possible that some form of assisted take-off will become absolutely indispensable. Also if long-distance raids are going to be made on Japan, is it not conceivable that jet or rocket engines shall be used?

Other aspects of jet reaction are equally interesting. If the exhaust system of the conventional aircraft power plant is suitably designed so that the gases expand, emerge at high speeds and give additional thrust, it is already possible to recover from the exhaust in our ordinary aircraft between 5 and 10 percent of the brake horsepower of the engine. Surely that should not be neglected. Strange as it may seem, radiators may also be made to deliver thrust. If a cooling radiator is placed in the wing, the air, when passing through the radiator, absorbs energy and heats up. Therefore, when it is led to the trailing edge of the wing the speed of the air is increased As a result, instead of the radiator producing resistance, it actually produces, by reaction, a rearward thrust. While neither the thrust reaction of the exhaust system nor the thrust of the radiator are any too high, they all help and the utilization of jet reaction and its thrust is being approached from many directions.

Even though the fuel consumption at the present moment with jet-propulsion is probably between two and three pounds a horsepower-hour, so that jet

(*Please turn to page* 192)

YOUNG MEN AT WORK—Inventions are almost certain to be opposed in their earlier stages by "official" scientists. They will be adopted by governments only after determined and lengthy effort. They are almost certain to come from young men. The opposition comes because it is always easier and safer to oppose. Young men are likely to be the inventors because they have greater imagination and greater optimism, and are less harassed by duties and affairs. The story of Group Captain Frank Whittle, inventor of the first succesful jet-propulsion engine, bears out these views. Dr. Edgar Buckingham, of the Bureau of Standards, as the result of an early study for the National Advisory Committee for Aeronautics, gave as his opinion that "the fundamental disadvantage of high jet speed and poor ratio of conversion of heat into thrust work would remain an insuperable obstacle to the use of such jets." In Captain Whittle's case it was not the Government that provided the classic opposition to a new idea, but industrialist after industrialist turned down the invention and the Captain was about to give up in despair. For five years he did nothing about the original patent taken out in 1930.

Frank Whittle is only 36 years old now, and it was while studying at Cambridge University that he explained his ideas to four of his friends—Johnson, Wing Commander G. Lees, J. C. B. Tinling, and R. D. Williams. Messrs. Tinling and Williams, former R.A.F. men who had a small business together, managed to raise some money and it was the enthusiasm of a group of young and air-minded men which was the greatest factor in carrying the venture to success.

'Our Business Is - - Improving'

Research Facilities are Made Available for Small Businesses Through the Activities of the Armour Foundation. Without Huge Investments, Industries that Cannot Otherwise Afford Research Laboraories are Placed on the Same Basis as Big Business

By FRANCIS SILL WICKWARE

SOME TIME AGO, an executive of a fountain-pen company took a plane trip He forgot to empty a brace of pens in his vest pocket before going aloft; when he landed, his vest, shirt, and undershirt were soaked with ink. This executive had written many advertisements which described his pen as "the ideal fountain pen." Obviously, the pen wasn't ideal if it leaked in an airplane. What, he asked himself, could be done about it?

Apparently nothing could be done. All fountain pens were constructed on the same time-honored principle. At high altitudes, lowered atmospheric pressure allowed the ink to leak. No manufacturer had succeeded in preventing this

Ink might still be oozing out of pens in planes, if the executive hadn't happened to hear of the Armour Research Foundation, an engineering and research institution affiliated with Illinois Institute of Technology. "We can make almost anything. We can improve anything. Within reason, we can invent anything." So states unorthodox Mr. Harold Vagtborg. 38-year-old Director of Armour Foundation In the case of the leaking fountain pen, which was accepted as a research project. Vagtborg and his colleagues characteristically attacked the problem by forgetting everything they had ever been told about pens. "What is this thing? What's it for? How does it work?" they asked.

Starting from the ground up, they first made a thorough study of the basic principles of fountain pens, then constructed a totally different pen which could be carried to the moon and back without losing a drop of ink. The solution — so simple that no one else had thought of it — was a pen with two reservoirs, one connected with the other At low altitudes, ink stayed in the main reservoir, as in conventional pens. At high altitudes, under reduced pressure, the pen leaked — but only into the *second* reservoir, which served to equalize external and internal pressures at all altitudes This improvement alone (and there were several others) led to such an increase in sales of the pen that the $7500 research cost was more than met in a few months.

Another example of the Armour Foundation's open-minded approach to industrial research was the Elgin Watch project. About three years ago, T. A. Potter, president of the Elgin company, arrived at the unprepossessing Armour administration building, a converted red-brick apartment building on Chicago's South Side. Potter brought with him an especially troublesome problem. Manufacture of certain watch parts, so small that 300 of them could be placed in a tiny thimble, was slow, difficult, and costly At one stage in the process these small pieces were heat-treated; and too often during this heat treatment whole batches fused and were useless. The result was that only one third of the total pieces produced were of the quality demanded for Elgin watches. Not even the master watchmakers of Switzerland knew how to overcome this difficulty

NO RESULTS, AT FIRST — Armour undertook the project and gave itself 12 months to find the answer. From the start it was obvious that the solution hinged on developing a new method of heat-treating the watch parts. Much work already had been done in this field, and all authorities and textbooks agreed on certain standard methods; but none of these methods worked to complete satisfaction.

For 11 months Armour Foundation men worked along conventional lines — and got nowhere. Then Dr. C. N. Challacombe, staff physicist, decided to throw away the textbooks and forget the authorities. Thirty days later he walked into Potter's office at Elgin, Illinois, and dropped a handful of the little watch parts on the desk. They were bright, new, perfect, and they didn't stick together. Once having freed his mind from the orthodox verdict that it couldn't be done, Challacombe had speedily invented an entirely new heat-treating method which depended upon more perfect furnace atmosphere control and which produced nearly perfect batches of parts.

In seven years Armour Foundation has grown from a name and a good idea into one of the most important institutions of its kind in the United States. The "good idea" was to provide an industrial research service for the particular benefit of small business. Of the 100,000 industrial and manufacturing companies in the United States, only 2000 have any research facilities of their own. A few giants like General Motors, Westinghouse, DuPont, Bell Telephone, General Electric, and Standard Oil have invested millions in their laboratories, but little business has no such sums to spend. To equip a modern laboratory would bankrupt most such companies.

The Armour Foundation will undertake a project in practically *any* field; nothing is too large or small, too simple or complex for investigation. It does a lot of work in long-range problems, but is also always ready to undertake short-term investigations for small companies which have day-to-day problems.

Checking noise on a new comptometer model, made quieter through research

In working out solutions to the problems presented, the Foundation pools the brains and experience of its staff of more than 200 technicians and research experts Many minds thus are constantly working on a great variety of projects. A chemist consulted on an engineering matter may have just the right slant that will lead to a solution. Conversely, an engineer may solve a problem in chemistry. It is *group* science, *group* research, that gets results

Armour is not endowed, it depends solely upon the income derived from "service fees" These fees range from $5 (for a minor problem) to $100,000 for several years of work on a long-range project. The average Foundation project costs the sponsor $8500 a year Clients frequently are so pleased with the results that they contribute money or equipment. A foundry equipment company gave $30,000 cash for the Foundation's "general welfare"; a steel company contributed a $20,000 induction furnace. Other donations include a multiple-stage hydraulic press, a testing machine which can crush concrete pillars, a Bessemer steel converter with electronic control, a spectrophotometer, and many other complicated scientific gadgets. All told, equipment worth $500,000 has been contributed

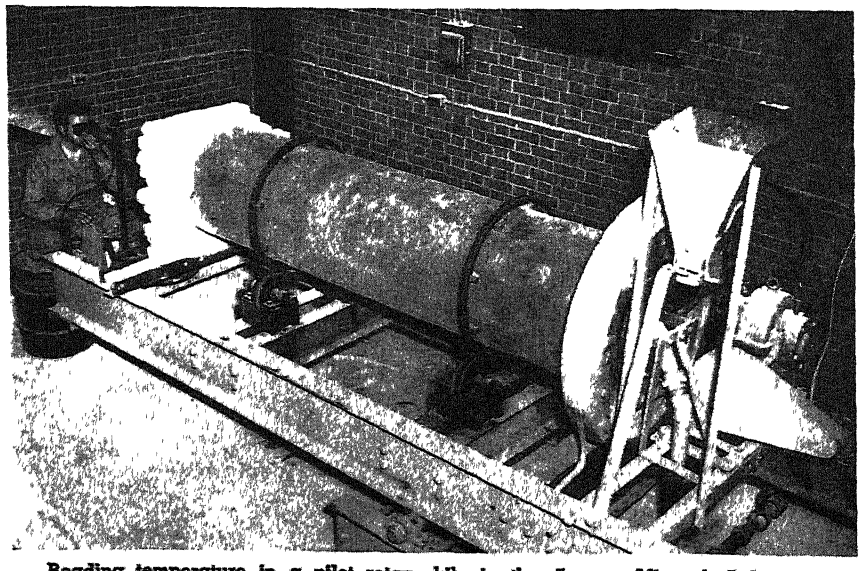
MINIATURE INDUSTRIAL PLANTS — Due to the practical nature of the research, many of the Armour laboratories are miniature industrial plants There is, for example, a complete, working flour mill, a candy factory, a rotary kiln for cement production, a midget steel rolling mill, an iron foundry, and a complete line of electrical equipment. Other facilities include a biochemical lab, a plastics lab, a shock test machine that develops impacts of 2000 foot-pounds, and a huge smelter where Armour metallurgists melt steel with ultra short-wave radio. There are elaborate photographic laboratories, with photo-electric, photomicrograph, stereocamera, and stroboscope apparatus, used mainly in stress analysis and in detailed studies of machinery operation. There is also a thermal chamber where artificial weather is manufactured to order. Here Armour tested strathosphere equipment for the Army, at a temperature of 67 degrees below zero, and with an artificial 200 m p h wind blowing. Another time, the exact climatic conditions of the South Pacific were reproduced in midwinter for tests of drums and containers used for storing aviation gasoline

Since Armour is willing to tackle practically anything, its projects cover the whole range of technology. At one end of the scale is the pioneering research into the behavior of lubricants under the terrific hydraulic pressure of 1,500,000 pounds to the square inch. At the other end of the scale was the problem of the candied cordial cherries, sold by newsboys on a western railroad. On certain trains — but not on others — juice leaked out of these candies One of the Armour researchers placed a box of the cherries in the Foundation's altitude chamber, and, sure enough, when the needle registered a pressure equivalent to 6000 feet altitude the cherries leaked Like the fountain pens, they couldn't stand high altitudes. Armour's suggested solution A reinforcing chocolate shell for the cherries. For this service the Foundation charged its client $15.

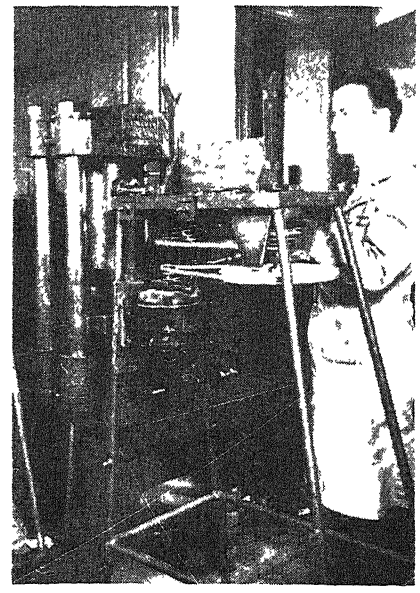
One of the most interesting things to come out of the Armour Foundation so far is a new sound recording device called the wire recorder. This was developed, not for a sponsor, or in the course of a project, but independently by an Armour staff physicist, 26-year-old Marvin Camras. Camras' cousin is a singer, and he wanted to make some recordings of his voice for study. Wasn't there a better way of recording sound than with the conventional, unwieldly disk-cutting equipment?

From his studies of electricity and magnetism, Camras knew that, back in 1898, a Danish scientist named Valdemar Poulsen had shown that it was possible to record sound with a series of magnetic "impressions" on metal. But Poulsen had never been able to lick all of the problems involved and finally abandoned his experiments.

With this background Camras set up an arrangement of magnets between which passed a moving steel wire. Sound waves were transformed into electrical impulses which, in turn, passed through the magnet windings. Thus, as the wire moved between the poles of the magnets, it received a series of magnetic impressions which corresponded to the original sound vibrations. Then, when the magnets were connected through amplifiers to a loudspeaker, and the wire was repassed between the magnetic poles, the sound was reproduced



Reading temperature in a pilot rotary kiln in the Armour Minerals Laboratory



High pressure investigation set-up

Camras noticed that as his wire slowly travelled between the magnetic poles it twisted and turned, distorting the sound He didn't realize it then, but this was what had been wrong with those earlier experiments Camras remedied this defect by bringing the magnetic poles very closely together and providing a tiny hole or groove for the wire. This one small improvement created a new recording instrument which can well make all existing phonographs and record-cutters obsolete. With the new wire recorder, eight hours of continuous sound can be recorded on a spool of fine wire five inches in diameter and ten inches deep.

VALUABLE NOW, AND POST-WAR — The wire recorder has so many military uses that it won't be available for civilians until after the war. In radio monitoring stations, for example, it takes down millions of words of foreign broadcasts. On the fighting fronts it is carried with advancing troops and records the sounds of an entire battle. In commercial planes, with microphone equipment, it serves as an automatic log of the flight, and—housed in asbestos—can survive a crash and recount the reasons for it. Now manufactured by General Electric under a non-exclusive license, with royalties shared jointly by Camras and the Armour Foundation, the recorder has proved so valuable that every completed unit is rushed to the services. Arrangements are currently being made with other manufacturers, each to produce the instrument for a specific field of application.

Peacetime uses of the recorder, which is not much bigger or heavier than a portable radio, will be tremendous. It will be possible to record everything from favorite bits of jazz to whole symphonies and operas, either by radio, or

FROM COAST TO COAST... GRATEFUL MULTITUDES HAIL

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TO THE hard of hearing men, women and children of America, a new world of happiness has been opened! At a cost which, for the first time, brings a fine type of hearing aid within reach of all the new Zenith Radionic Hearing Aid is lifting the cloud of misunderstanding and missed opportunities from the lives of those who have *suffered in silence.*

As this mighty Zenith crusade sweeps ahead, it is *revolutionizing* the cost of hearing. It is enabling men and women to be restored to full usefulness in vital wartime work . . . children to be saved from failure and unhappiness . . . the hard of hearing, and their families and friends, to rediscover the enjoyment that comes when normal sounds are heard again.

From coast to coast, America has given this crusade an enthusiastic welcome. The proof is in the deluge of orders pouring in from every part of the nation . . . orders which *continue* to exceed all anticipation. Please accept our apology if you have been unable to secure a Zenith Radionic Hearing Aid. We are making every effort to supply the demand. Our production is increasing daily, but we shall *never* break faith with our hard of hearing friends by sacrificing quality for speed or quantity.

You have waited years for this crusade that lowers the cost of hearing. Note carefully the advantages which the new Zenith Radionic Hearing Aid now brings you—and we feel sure you will decide never to pay *more* and get *less* in a hearing aid. You will find it worth your while to wait a little longer, if necessary, until Zenith's precision production facilities can meet the needs of your community.

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2 Four-Position Tone Control. The flick of your finger instantly adjusts it to the effective combination of low, medium and high tones for individual needs in varying surroundings, hearing deficiencies in any range. No further adjustments needed.

3 Special Battery-Saver Circuit. Insures economy in battery consumption . . . results in substantial saving of battery life and battery replacement expense.

4 Zenith Quality—Zenith Guarantee. Zenith, world's leading manufacturer of radionic products exclusively, is fortunate in having the knowledge of precision production that makes possible this quality hearing aid at a remarkably low price. Guaranteed for a full year, with unique service insurance plan.

The Zenith Radionic Hearing Aid is available through reputable optical establishments franchised by Zenith.

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Complete with Radionic Tubes, Crystal Microphone, Magnetic Earphone and Batteries. One *model*—no "decoys"... one price —$40 . . . one *quality*—our best. Covered by a liberal guarantee.

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To Physicians: A detailed scientific description will be sent upon request. Further technical details will appear in medical journals.

*

There are cases in which deficient hearing is caused by a progressive disease and any hearing aid may do harm by giving a false sense of security. Therefore, we recommend that you consult your otologist or ear doctor to make sure that your hearing deficiency is the type that can be benefited by the use of a hearing aid.

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in theaters, night clubs, and concert halls. It will be available to record speeches, meetings, conventions, court trials, sessions of Congress.

[Editor's Note: It should be noted here that one of the reasons why earlier experimenters in the field of magnetic recording were unsuccessful was the lack of adequate means of amplification, now available in the vacuum tube. Early reproduction was faint and too noisy to be useful. However, in the 1930's, Dr. C. N. Hickman of the Bell Telephone Laboratories took up the investigation in the light of modern techniques. He used a tape of very retentive magnetic material a thousandth of an inch thick and a few thousandths wide, rather than the wire employed by Poulsen. Thus were eliminated the troubles due to twisting of the recording medium A number of commercial applications have been made of Dr. Hickman's development, notable among them being the weather-forecast service offered by several telephone companies; a recorder for incoming news dispatches used by two New York newspapers; and the Mirrophone, a portable device used for voice culture and study whereby one can immediately play back a recording of one's own voice.]

NOISE REDUCTION — Armour research already has affected millions of people through improvement of common articles and commodities in everyday use Contributing to the comfort and efficiency of office workers was a project sponsored by the Felt and Tarrant Company, manufacturers of the Comptometer. The machines were noisy; the din of a battery of them distracted everyone within earshot, increased fatigue, and impaired the efficiency of an entire office. This had been proved by exhaustive studies. In 1938 R. J. Koch, head of Felt and Tarrant, turned over the noise-removal job to Armour. Under the direction of Dr. H. A. Leedy, Armour research eliminated 94 percent of Comptometer noise. As is often the case in such projects, it was possible to eliminate much vibration—and, hence, noise —merely through changes in shape and mass of certain parts. In addition, the use of special materials contributed further to the absorption of some vibrations that could not otherwise be eliminated.

Of great potential importance to home-owners and motorists is a new fuel—half oil and half coal—developed during a project to discover possible uses for coal dust, which always has been a nuisance and a waste around mines. The Foundation discovered that finely pulverized coal dust suspended in low-grade oil made an excellent heating fuel of great economy, and that with certain adjustments and changes in the fuel-handling system a stock-model automobile could be driven on it. The Foundation doesn't think that the new fuel will take the place of gasoline right away, but if the motor-fuel shortage becomes more critical it might be used as a substitute.

Failure sometimes is as gratifying to a client as success. Recently, the Foundation was forced to admit to an important client that after two years it had made absolutely no headway with a confidential problem he had brought in. At this the client smiled, rubbed his hands, and said: "Gentlemen, the project has been eminently successful. You've convinced me that I can't improve my product the way I wanted to, and you've also convinced me that my competitor can't improve it either."

One of the major activities of the Foundation is the National Registry of Rare Chemicals, outgrowth of a rush project undertaken early in 1942. The work required a quantity of a rare compound designated as "1, 1 dichloro 1 nitro ethane." None of the well known chemical companies or laboratories had any of the stuff, and it took Armour a month to find what it needed, thereby

Checking the frequency response of new magnetic wire sound recorder

endangering the whole project. This convinced the Armour staff of the need for a national clearing house for hard-to-find chemicals. The Armour Registry does not stock any chemicals, but keeps the names of some 6000 on file, with directions for producing them. So far it has received over 2500 requests—many from foreign countries—and has been able to answer 75 percent of them, usually within a couple of hours.

Today Armour Foundation is 100 percent devoted to war products. Many technological wonders lie hidden behind the veil of military secrecy, but Director Vagtborg is free to make some predictions about the future. One of these concerns "radio cookery," an outgrowth of diathermy and "artificial fever" treatment. He prophesies that we shall have electronic cooking as a generally accepted commercial practice, but doubts its use in the home because of the hazard of high voltage. One commercial company has already perfected a thermal radio hamburger and hot-dog vending machine. The customer drops a coin into a slot, and after half a minute a radio-cooked morsel pops out.

In choosing personnel, the Armour motto has been "Get the man who is arriving, not the man who has arrived." The result is a group of "boy geniuses" of science. The assistant director of the Foundation is 33 years old—slight, blond-mustached Dr. Francis Godwin, who looks like a college freshman, but who is already a world-famed chemical engineer. The heads of chemical engineering and engineering mechanics likewise are in their early 30's.

Once every summer Director Vagtborg takes his section heads and senior staff members off on a busman's holiday to the North Woods. There, cut off from communications with the outside world, they hold policy conferences and devote four hours a day to intensive study of problems. The rest of the time they fish. "The fishing is essential," Vagtborg comments. "It breaks down stratification and cliques, failings which are in the scientific tradition It gets the men together again and helps their minds to mesh In fact, it's an important part of the Armour Plan."

The essential, long-range purpose of the Armour organization is to give small business a chance to compete with big business on equal terms, as far as research is concerned. The Foundation has already served 1100 companies in this way

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TINY FLUORESCENT

Lamp Operates on Small Fraction of a Watt

NO LARGER than a marble, a new fluorescent lamp has been developed that operates with remarkable efficiency. It gives off more light than a quarter-watt neon glow lamp that consumes two and a half times as much power, according to Westinghouse engineers. For the first time, modern fluorescent lamp efficiency has been obtained in a miniature-size light source. Thirty of these tiny bulbs take no more energy than an electric clock. This economy adapts the new lamp to many military applications where very little energy is available. Using energy from dry batteries, it might be used to mark a cache of supplies to be left unattended for months It could also be used as a flashing lamp on life rafts. If available after the war for household use, the lamp could burn constantly for six months (to mark a stairstep or keyhole) for about a cent's worth of electricity.

HYDROPONICS

Success Based More on Seedbed than on Chemicals

HYDROPONICS is the name applied to the science of crop-production in seedbeds placed over shallow basins of water containing chemicals. The roots of the plants grow through the bed into the solution below. It has been found that water changes roots from their soil types, and that the formulation of a new science which would require volumes to explain is based on this root change.

The basis of hydroponics is found in the properties of water and of the seedbed which take the place of the non-nutritive fraction—99.99 plus percent—

of the soil that constitutes the normal home for the roots. The chemicals added to the water substitute for the nutritive fraction of the soil. Successful hydroponics depends largely on arranging the seedbed to the requirements of an altered root system, as described in the author's book, "Complete Guide to Soilless Gardening."

Soilless crop-production has been widely misconceived, as is evidenced by the use of such terms as chemical gardening, nutrient culture, and so on These misconceptions did great harm to the new science, as they wrongly inferred that the chemicals, instead of the substitutes for the non-nutritive fraction of the soil, determined the dynamics of the method.

Garden vegetables can be grown economically by hydroponics, since land-fertilizer grades of chemicals are entirely satisfactory for addition to the water. Increased production soon compensates for investment in equipment. Any one can be successful in growing garden crops without soil if he bases his procedure on the influences of water and the seedbed, and does not expect miracles from the chemicals—*W F. Gericke.*

CORE RESIN

Reduces Demands For Foundry Sand

FACED WITH a scarcity of the specially graded silica sand used in cores and molds to shape tough cast armor steel, foundries have greatly increased their use of mechanically-reclaimed old sand by mixing it with a pulverized resin. Before the war, production of each ton of cast steel usually required half a ton of new sand.

As an illustration of how much sand has been saved for re-use by the inclusion of the resin, the Hercules Powder Company cites one large foundry turning out 5000 tons of steel castings monthly. By using the resin, which is extracted from southern pine wood, this foundry has sliced its new sand requirements from 2500 tons to 600 tons monthly.

The resin core binder has shortened production time because it bakes faster than other type binders and it has been found especially effective with sands containing clays. Truline Binder, the Hercules resin, also provides unusual dimensional accuracy in the sand shapes.

ULTRASONIC WAVES

Are Being Put to New Military, Industrial Uses

IN 1927 Professor R. W. Wood and Mr. A. L. Loomis of Tuxedo Park, first described the physical and chemical effects which can be caused by the application of intense sound waves to various physical, chemical, and biological systems. Since then, high-intensity sound waves of audible and inaudible (ultrasonic) frequency have become, through the efforts of numerous investigators, a valuable tool in many branches of science. One of their main fields of application is colloid chemistry, the science of matter in a finely dispersed state, which deals with emulsions, suspensions, proteins, starch, rubber, fogs, smokes, and other similar materials.

By the application of high intensity sound waves, according to a paper by Professor Karl Sollner, University of Minnesota, presented before the Division of Colloid Chemistry of the American Chemical Society, many materials may be dispersed to form colloidal dispersions. That is, emulsions may be obtained if a vessel filled partially with oil and partially with water is exposed to the action of sound waves of audible or inaudible frequency.

On the other hand, emulsions may be destroyed, "broken," as the colloid chemist says, by sound treatment of low intensity Many soft, solid materials may likewise be dispersed by sound action to form colloidal suspensions which conventionally are prepared in so-called colloid mills. Scientists of the Bureau of Mines in this country and others abroad have demonstrated that sound treatment of fogs and smokes leads to the aggregation (coagulation) of the droplets of fogs and the particles of smoke, so that they may settle readily, leaving the air clean and free from foreign material. This technique may soon find a wide application in the fight against the smoke nuisance and at the same time allow the recovery of valuable and rare materials otherwise lost through the chimney.

Useful applications of intense sound waves outside the field of colloids in-

. . . Eyes Grow, too

There is more to proper visual care than merely fitting a pair of glasses. Take this youngster, for example. Let's remember that bodies are less mature at 13 than at 15. His eyes need correction today. But how quickly is this condition likely to change? How much provision for the future should be included in his prescription? Is this boy the active outdoor type or is he one who likes to read hour after hour?

Many other factors, too, demand consideration. Only a man qualified by skill and experience is competent to evaluate such important questions. His professional analysis includes not only the patient's present condition, but also the years that lie ahead. Those years can be richer if priceless vision is maintained at its highest possible level of performance.

The human eye is a complex and marvelous structure. Proper provision for its needs demands a high order of professional skill. See that your child's eyes—*your* eyes—receive the benefit of such trained care.

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clude their marine application in the detection of submerged objects in water, such as icebergs and ships. This is today an indispensable help to navigation in war and peace. Sound waves are also used to test large metal castings for cracks and holes, which frequently cannot be detected by the usual X-ray methods. Gas bubbles or fine fissures prevent the regular transmission of the sound wave in the metal; thus any irregularity in the sound transmission indicates a dangerous weakness in the metal casting.

DRYING OIL

Made from Castor Oil by Simple New Treatment

FOR SEVERAL years prior to the present war some of the manufacturers of paint oils had started to make a drying oil from castor oil. Ordinarily castor oil is a non-drying oil, but by a rather simple chemical treatment it can be converted into an oil which compares quite favorably with China wood oil (otherwise known as tung oil) in its drying properties. This latter oil has for many years been very important in the formulation of varnishes, and shutting off of supplies from the Orient would have been a very serious matter if there had not been this substitute made from common castor oil.—*The Research Viewpoint*, Gustave J. Esselen, Inc

BARGE LININGS

Protect Gasoline from Concrete Reaction

A NEW job for synthetic rubber—transporting and storing millions of gallons of high-octane gasoline at strategic coastal points and island air bases—is being accomplished by the use of a new synthetic rubber "latex" to line concrete gasoline barges and underground storage pools. The new "latex," or water-dispersion of particles of synthetic rubber, which is resistant to the highest octane fuels now coming into extensive use, was developed by the Thiokol Corporation.

Early in the war concrete barges and tanks were eyed by engineers as a possible solution to the already critical steel supply, but were in themselves useless for gasoline transportation since the alkalies in concrete react to form gum in the gasoline and lower the octane rating. In a new process developed for the U. S. Navy by Stoner-Mudge Inc., fabric of the type used for camouflage cloth is cemented to the concrete with the Thiokol "latex" and coated with the same material. The result is a gasoline-resistant container which protects the contents of the tank from the alkalinity of the concrete and which will bridge over normal cracks in the concrete caused by shrinkage, settling, and unusual stresses.

COAL-TAR FUEL

By-Product of Coke Ovens Used Successfully

SUBSTITUTION of a relatively plentiful fuel in place of oil has effected a saving of 25,000 gallons of fuel oil daily at the Rouge plant of the Ford Motor Company. The substitute is coal tar, a by-product of the Rouge coke ovens.

The open hearth furnaces at the steel mill ordinarily are heated with fuel oil. Substitution of tar, however, involved no mechanical changes, since the heating values of both fuels are substantially the same and both are injected under steam pressure.

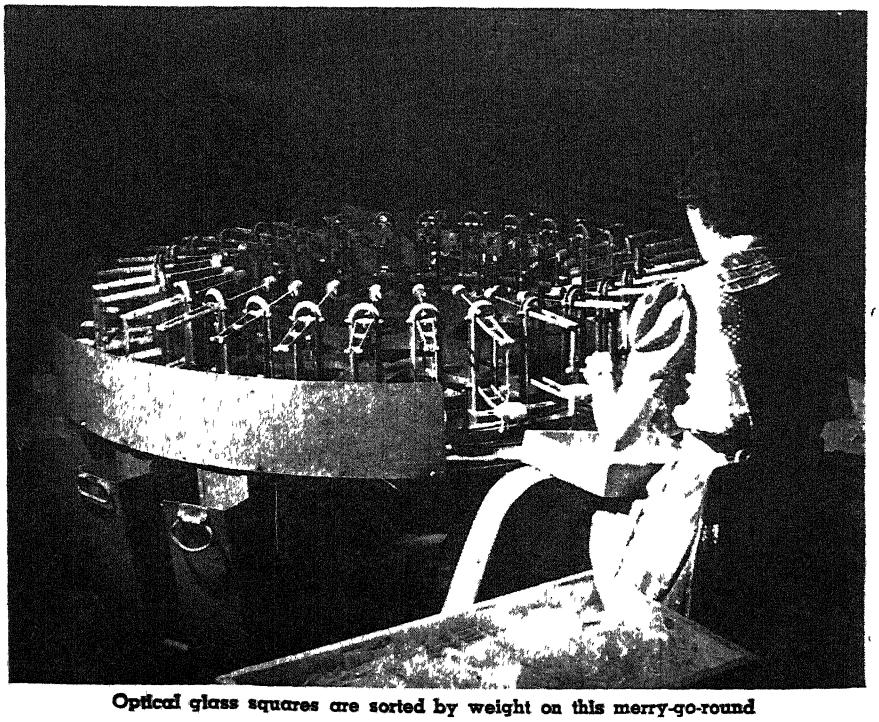
WEIGHT SORTING

Accomplished on Balance Merry-Go-Round

SPEEDING up the war effort in the precision lens field is a merry-go-round on ball bearings, carrying an endless procession of balance scales past a single operator, which does the work of 20 individual sorters and weighers in the glass plant of the Bausch and Lomb Optical Company.

Small squares of optical glass, which must be accurately weighed before being molded into lens blanks, are placed on each balance as it passes the operator. The scales are set to weigh within one gram (about one twenty-eighth of an ounce). Attached to the pan of each scale is a trip lever which automatically dumps the glass into the proper bin.

The heaviest pieces are tripped at the right of the operator, with each succeeding bin receiving blanks weighing



Optical glass squares are sorted by weight on this merry-go-round

one gram less than the preceding one. A bin is provided to take blanks weighing more than the maximum and another to receive those below the minimum weights.

There are 30 balances on the machine, which makes two revolutions per minute. All the operator does is to place a piece of glass on each scale as it passes. The machine does the rest, sorting each piece by weight.

NYLON ROPE

Exhibits Unique and Valuable Properties

NYLON ROPE, whose unusual properties have demonstrated their value under the severe test of invasion glider operations, can be seen stretching into the future to perform a variety of useful civilian tasks.

In its combination of strength, lightness, and durability, nylon is equaled by no other fiber rope. A nylon rope approximately one half inch in diameter can lift a load of three tons and is about twice as strong as a manila rope of the same thickness. Nylon rope is, furthermore, one half to two thirds as heavy as manila rope of equal diameter. But its peculiar elasticity is the quality which makes it unique

A rubber band or a steel spring has an elasticity which expresses itself in a quick snap. Nyon rope, in contrast, has a slow, gentle bounce. Under the stress of a sudden pull, the nylon rope stretches rapidly but recovers slowly, the action desired in the perfect shock absorber.

The scientific explanation of this behavior is hysteresis—a lagging or retarding effect due to internal friction. In a sense, hysteresis is the conversion of energy into heat. When you stretch a rubber band the energy you put into the action is stored up in the rubber, ready to snap it back the moment you let go. Energy is similarly stored and quickly released when a steel wire or cable is stretched. But when you stretch a piece of nylon rope, much of the energy goes into heat and only a part of it is converted into recoil, making a smooth shock-absorbing effect.

Its shock-absorbing property gave nylon rope its first job, back in 1940, picking up airmail in a non-stop service operated by All-American Aviation, Inc. Before nylon rope was adopted, a hydraulic shock absorber was used to ease the strain when the mail bag was picked up "on the fly." But the nylon proved to be much simpler, lighter, and more efficient.

When the Army entered the glider program it, too, tried first a mechanical shock absorber, with steel cable on the glider nose and on the pick-up winch. But the Army eventually hung its hopes on nylon rope.

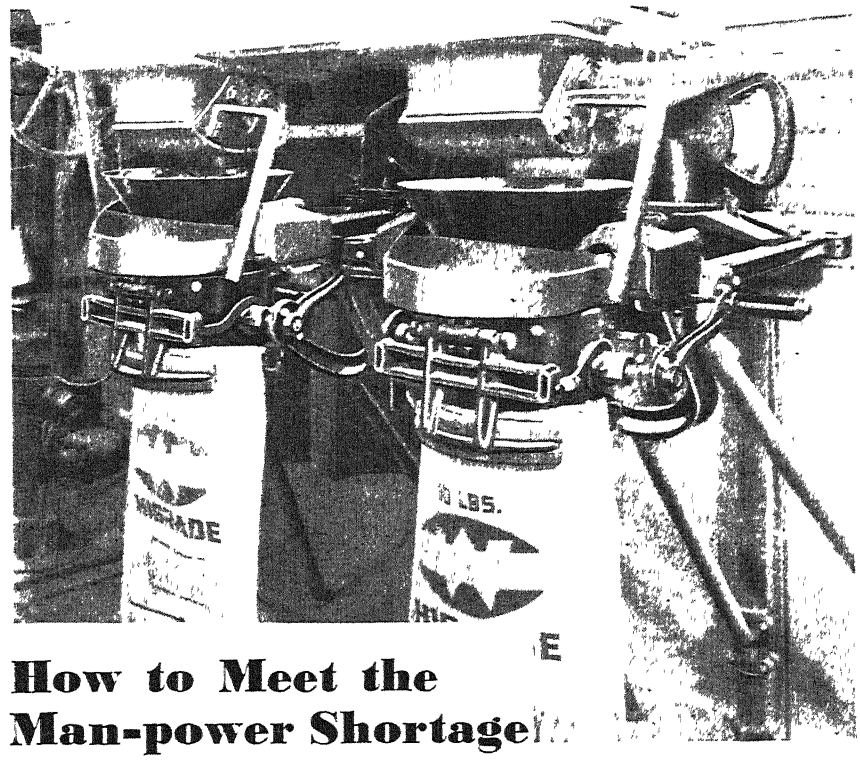
Most of the glider operations to date, including the transatlantic cargo trip and Sicilian invasion, have been straight tow maneuvers in which plane and glider leave the field together. But non-stop pick-up has been demonstrated many times, with large as well as small gliders, and nylon rope has turned in a successful performance. Pickups are seen as particularly useful for rescuing isolated troops or wounded men from a spot too cramped for a plane landing, or for moving fighters from such a point to the next assignment. A glider could be landed in the small area and then picked up after loading.

Some of the climbing ropes employed by the Army's mountain troops are also of nylon, which provides strength with less weight and is thus easier to carry. Nylon likewise absorbs much less water than does manila, another weight advantage in rainy weather. The shock-absorbing property is an obvious benefit when a soldier slips and is checked in his fall.

The post-war world should find nylon rope's opportunities greatly broadened. There are applications on file from 1800 towns and villages who want non-stop airmail service, and availability of planes after the war should permit this expansion. The late Richard du Pont foresaw, and his associates of All-American Aviation, Inc., still see, room for cargo and passenger gliders serving as feeder lines for the larger airways. Powerful tugboats of the air could pick these up non-stop at the small towns and drop them over landing fields of the through airlines.

These and other applications of nylon rope would benefit by its high resistance to abrasion, which makes it outwear manila. After a million rubs across a metal bar, in abrasion tests, nylon was still good, whereas manila wore out in 200,000 rubs.

Nylon's resistance to the damaging



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effects of mildew and salt water, in addition to its strength, lightness, and elasticity, suggest many other post-war applications for nylon rope. But actual trial in many new tasks must await the day when there is no longer such a heavy demand for nylon yarn in its major job—helping to win the war

STURDY FLOORS

Made of Specially Designed Panels

A LIGHTWEIGHT floor, which is also sturdy and capable of withstanding a lot of abuse and scuffing, consists of a top surface of a plywood known as Ply-Tech, a bottom surface of the same material, and a core of spruce wood, made

Weight test of new floor panels

up of narrow grid strips. The result is a floor panel less than ¾-inch thick, with a weight of approximately .85 pounds per square foot, that will support an ultimate load of 800 pounds per square foot on 18-inch spans. Since the core of this floor is hollow, provision is made for necessary bolt holes by dropping small blocks of wood into cubicles of core before pressing, thereby giving solid construction where necessary.

Hollo-Tech, as this type of floor is called, presents its best strength factors when made in large panels. Floor panels up to 25 feet long and 4 feet wide are being made. The continuous length over a multitude of supports lessens the possibility of deflection due to unequal loading of spans.

GEAR SHAVING

Shows Notable Savings Over Grinding

A SAVING of 40,000 man-hours a year in the production of vital Flying Fortress engines was announced recently by The Studebaker Corporation. The economy results from an application of shaving machines to a 15-tooth pinion gear which is carried in sets of 20 on each Wright-designed Cyclone. Important machine conservation and reduction in scrap is likewise reported for the revolutionary method.

According to George W. Bunner, general manager of the Fort Wayne Studebaker aircraft engine parts plant, a single worker on gear shavers can produce as many units as five on grinders, until now the conventional machine for shaping finished aircraft engine gear teeth. Scrap has been all but eliminated by the fact that in-built precision of the shavers reduces the possibility of human grinding errors.

With conventional gear grinders, it is necessary to re-form the grinding wheel after every piece; the high speed steel cutting tool used in the shaving machines is reported to be good for 5000 pieces and each tool will take four re-grinds A run of 25,000 pieces is thus possible before replacement of the tool

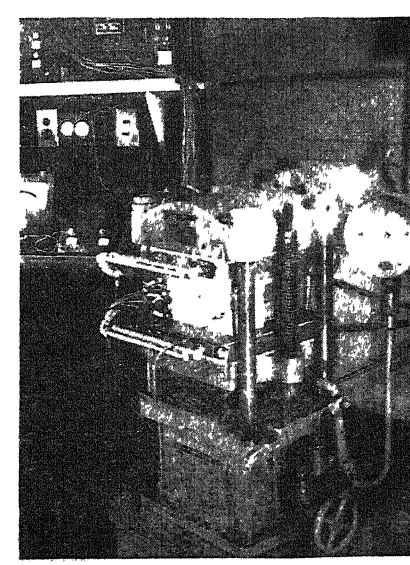
WOOD GLUING

Speeded by Application of Resistance Heating

SHORTENING the assembly period during the manufacture of laminated timbers from a week to about five minutes, with a better quality of gluing, a new gluing method was recently announced by Dr. W. Gallay and Mr. G Graham of the Division of Chemistry, National Research Council, Ottawa, Canada. The method has already been tried out on a large scale and will be ready shortly for commercial use. It consists essentially of a novel means of generating heat directly in the glue line in order to set the adhesive irreversibly

This is accomplished by adding a conductor—acetylene black—to the glue so as to render the glue line conductive. Electrodes placed along the edges of the glue lines are connected in parallel, and the glue is then heated by low-voltage current of ordinary characteristics, such as D.C., 60 cycle A.C., and so on. The heating is essentially similar to that in a toaster or heating pad. The method is very simple, requiring no apparatus, no plant conversion and no trained personnel, and is to be sharply distinguished from radio frequency heating from which it differs entirely, and over which it has advantages for gluing large-scale work.

The quality of the bond obtained with resistance heating is very good, and large scale trials conducted in an air-



Resistance heating set-up for gluing

craft plant have shown that the procedure is rapid and efficient

The new process, it is expected, will open a new field of utilization for laminated wood, not only for many important war uses, but also for general construction and engineering application in post-war uses.

GAS DETECTOR

Uses Photocell of Limited Response

A VIGILANT "safety patrolman," with an electric eye that can see the ghostly shadows of many otherwise invisible gases and vapors, has been developed by Du Pont scientists to warn of dangerous concentrations of these compounds in the atmosphere of manufacturing plants.

Known as an ultra-violet photometer, the instrument is faster and simpler than analyzers previously used and it is so sensitive that it can detect one part of carbon disulfide, for example, in a million parts of air. Similarly faint whiffs of other volatile compounds are quickly detected by this electrical watchman.

The problem of contaminated atmospheres is one with which many industries are concerned. Elaborate air-conditioning systems, special section hoods, and so on, are employed in plants to draw vapors and gases, and in many situations the workers themselves wear gas masks during certain operations.

It is necessary, however, to make periodic checks of the air in various parts of the plant to ascertain whether the concentration of the volatile substance is being held within the safety level.

Most analyzers previously employed required 15 minutes or more to take an air sample, which therefore represented only the average concentration of the gas during that period of time. Momentary high peaks escaped observation. The instrument developed by Du Pont, on the other hand, can take quick "grab samples" or run continuous samples and give direct and instantaneous readings. This permits accurate second-by-second observation of the vapor level in each step of a manufacturing process. For this reason boards of health, insurance companies, and industrial engineers have found the analyzer helpful in determining hazards and in arranging equipment and planning air-conditioning systems and exhaust flues to render working areas safe.

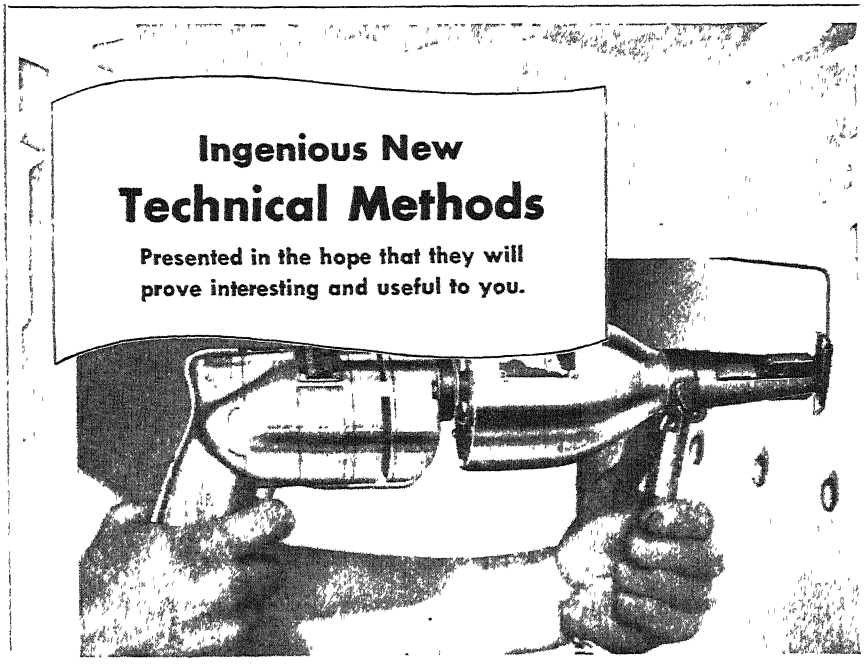
V F. Hanson, of the Electrochemicals Department of Du Pont, designed the original instrument and a modified model, intended particularly for carbon disulfide analysis, has been developed by Dr. Shirleigh Silverman, assisted by Dr. J. W. Ballou and W. H. Warhus, all of the Rayon Technical Division of the company. The Mine Safety Appliance Company is planning to manufacture instruments of this general type.

Operation of the ultra-violet photometer is based on the phenomenon of light absorption by gases. Most gases, including the constituents of the air itself, absorb light of some particular wavelength and thus throw a shadow where light would otherwise have fallen. In a spectrum that shadow is known as an absorption line.

Carbon disulfide, for example, strongly absorbs light having a wavelength of 3132 angstrom units. (An angstrom unit is equivalent to 39 ten-billionths of an inch.) Light of this wavelength is in the ultra-violet range, invisible to the human eye but not to the electric eye, which in the case of the analyzer is a sodium photocell.

The carbon disulfide analyzer is so constructed that the air to be analyzed is pumped through several small chambers, which filter out dust, oil, and moisture, and thence into a pair of parallel tubes, about 31 inches long The contaminated air runs into the first tube and then through a canister of activated charcoal which removes the carbon disulfide and passes the purified air into the second tube In this way there may be a continuous comparison of the purified with the contaminated air and very minute differences may be detected.

Rays of invisible ultra-violet light from a mercury lamp pass through the two tubes and fall upon a photocell mounted at the opposite end of each tube. The optical system, including filters, has been so selected that about 60 percent of the photometric response of the cell is due to light 3132 angstrom units in wavelength, the light which carbon disulfide absorbs. No other atmospheric element has been found in plants where this instrument is used that absorbs either this band of light



New Saw-Gun Saws and Files in Hard-to-Get-At Places

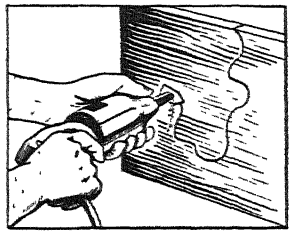
Jobs of sawing and cutting that are inaccessible to ordinary tools, are now made possible with the recently developed Saw-Gun. It works equally well on wood, plastics, light and heavy gauge metals (corrugated or plain—stainless and monel), castings, rods and other materials. The Saw-Gun saves hours on panel notching and slotting operations, doing work ordinarily requiring the use of several tools.

It is propelled by electric power, compressed air or flexible shaft and provides an efficient portable power-saw or file, that can be carried from place to place.

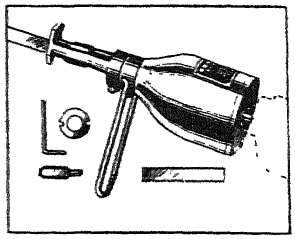
The Saw-Gun is operated by placing cutting edge of saw blade against work and turning on power. Filing is accomplished in the same manner by inserting a file in the tool instead of a saw blade.

We hope this has proved interesting and useful to you, just as Wrigley's Spearmint Gum is proving useful to millions of people (much to their surprise) working everywhere for Victory.

You can get complete information from the Mid-States Equipment Company, 2429 S. Michigan Ave., Chicago 16, Ill.



Permits sawing and filing in spots inaccessible to ordinary tools.



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or the 3650 angstrom unit band, which accounts for most of the remainder of the photocell's response. Therefore, when the analyzer "bats its electric eye" the operator knows it has seen the "shadow" of carbon disulfide. One part of this vapor in a million parts of air will produce an absorption of .02 of 1 percent, which is detectable by the instrument.

As an example of how the analyzer is used, Dr. Silverman cites a test in which 61 readings were made during the nine minutes required to open, dump, and clean out a large vessel in which material was treated with carbon disulfide. During most of the operation the concentration of gas remained below 20 parts per million and older methods of analysis, which could give only the average for this entire time interval, would show no danger points. However, the watchful photocell revealed that the concentration rose to 60 parts per million at one moment and to 40 at another. The ventilating equipment was therefore modified in order to eliminate these peaks.

TURBINE BLADES

Radically Improved After Long Research

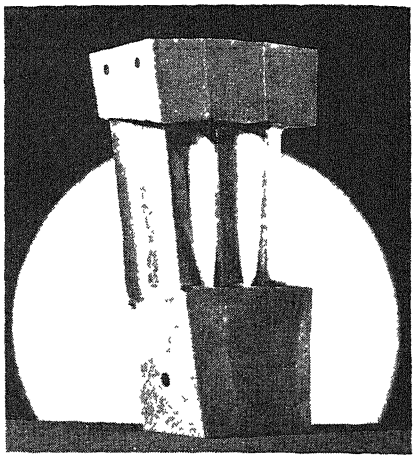
SOME studies of turbine impulse blades begun four years ago have been completed. A great deal of engineering drama and much of peace-time technical significance lie behind those words

The middle 30's saw the size of high-speed (3600 revolutions per minute) steam turbines, for superposition over existing units in power houses, being rapidly increased. In three years the largest size of this type was extended from about 15,000 to approximately 50,000 kilowatts. Steam engineers, in crossing these new frontiers, found themselves faced with new conditions Impulse blades made correspondingly stronger, according to previous practice, were not strong enough. The established design rules no longer held in these new regions of temperature, pressure, vibration, and so on.

As a result, Westinghouse inaugurated a long, painstaking program of theoretical and laboratory studies. A special test turbine was built and a unique scheme was devised for taking photographic records of blade behavior with the turbine in actual operation. In this four-year study several types of blades have been tested using a wide variety of temperatures, loads, and speeds. Long endurance runs have been made and about 120,000 photographic records were taken on about six miles of film.

Out of this enormous mass of engineering data has been evolved a superior, yet very simple impulse blade. The root by which it is fastened to the turbine rotor is shaped like an inverted U. Three of these blades are brazed together, forming one solid segment. Each three-blade segment is fastened to the rotor by two crosswise pins.

The new blade is smaller than the old one—one and one half inches wide instead of two. Old-design blades (which are larger) failed in less than 20 hours under grueling tests—the new



One segment of new turbine blades

blades pass a life test of 1000 hours with no indication of weakening. Experience shows that if a blade fails at all, it will do so in a relatively few hours. Fortified with a great deal of new design information about impulse blades, turbine engineers are ready to move to new levels in turbine construction when the central-station industry needs—and is able to obtain—larger, more powerful, high-speed generating units

"SECONDARY" CHEMICALS

Required in Huge Quantities for Synthetic Rubber Production

THE CURRENT Government program calls for the annual production of 850,000 long tons of synthetic rubbers 735,000 tons of GR-S (Buna S); 75,000 tons of GR-1 (Butyl); and 40,000 tons of GR-M (Neoprene). In addition, smaller amounts of Buna N, Chemigum, Hycar, Koroseal, and Thiokol are being manufactured by private companies. Aside from the chief constituents—butadiene, styrene, isobutylene, isoprene, and chloroprene—many other chemicals are required, and although their proportions are small, the total amounts are great. In the processing of the synthetic rubbers, moreover, still other substances are needed; some of these are the same as those used in processing natural rubber, but in greater proportions; some are quite different. The total amounts of all these "secondary" chemicals reach staggering figures.

These additional chemicals are both inorganic and organic. Large amounts of alum and soda ash, for example, are required to soften the water used in the polymerization process; sodium metaphosphate is used for preventing corrosion in pumps, pipe lines, and tanks; chlorine is employed to keep down slime formation in apparatus; anhydrous ammonia and brine are necessary to furnish refrigeration; tons of rock salt and much sulfuric acid are used in solution to precipitate or coagulate the synthetic latex.

Organic stabilizers, little-known compounds which prevent the premature polymerization of the butadiene and styrene while in storage, are present in only about 0.02 percent. Yet on the basis of 748,600 tons of butadine, this

small proportion means about 150 tons, or a third of a million pounds Furthermore, these stabilizing agents must be removed before the material is emulsified, and for this a solution of sodium hydroxide is required.

The emulsification of the butadiene and styrene requires great quantities of soap—pure sodium stearate. The plants are designed to use soap itself or to make the soap from stearic acid and sodium hydroxide The polymerization catalyst is added to the emulsified materials, and later a reaction stopper or anti-polymerizing agent is used to arrest the polymerization at the proper stage. This reaction stopper may be an antioxidant and therefore serve a dual purpose.

Larger proportions of softeners are generally required in GR-S than in natural rubber. If at least 5 percent of a softener is used in every GR-S compound, the total amount would be 36,750 tons or somewhat over 82,000,000 pounds! Softeners must be cheap and the important ones come from coal tar and turpentine products. High-boiling esters such, for example, as dibutyl phthalate, dibutyl sebacate, and so on, are in favor in the processing of some of the synthetic rubber compounds.

Organic accelerators are important in the vulcanization of GR-S compounds. as with natural rubber. There are variations in the effects obtained, but mercaptobenzothiazole is the leader in both cases Tetramethylthiuram-mono-sulfide and mercaptothiazoline are also useful. The aldehyde-amine type of accelerator. like the butyraldehyde condensation product with aniline, acts best as a secondary accelerator to "boost" the action of those just mentioned From 1 0 to 1 5 parts are generally used to 100 of the synthetic rubber On the basis of 735,000 tons of GR-S, 1 percent means 7350 tons of accelerators

In the manufacture of Butyl rubber. boiling ethylene is used to refrigerate the reaction mixture. The manufacture of Buna-N requires sodium oleate as the emulsifier. salt for the coagulation. and antioxidants for stopping the polymerization Furthermore, reclaimed rubber is closely connected with the entire program and the amount now being made is almost double the pre-war production Here caustic soda and oils from the coal and pine tar industries are widely used.

"Research is the price of progress," and surely at this time, with the wonderful co-operation of rubber chemists and engineers in the great synthetic rubber program, we can expect marvelous advances in rubber technology, and the application of many new chemicals to make the synthetic rubber do even more than natural rubber could do.—*U.S.I. Chemical News.*

FUNDAMENTAL KNOWLEDGE

But Little Advanced by War-Necessitated Research

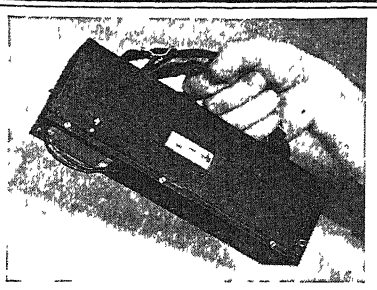
ALTHOUGH the war has been responsible for many new inventions, it has added little to the world's store of fundamental knowledge, Dr. Frank B. Jewett, vice-president of the American Telephone and Telegraph Company, recently told members of the New York University Institute on Post-War Reconstruction.

According to Dr. Jewett, only a few of the many technical discoveries which have been made since the war began will have peace-time applications. Progress in certain fields of scientific knowledge, he said, has been offset by a virtual cessation of research work in others that are not considered essential to the war effort.

"While the war effort has produced astounding technological results in many sectors it has on the whole added little to our store of fundamental new knowledge." Dr. Jewett said. "In the main it has been an intense utilization of accumulated knowledge and skills for a particular limited objective. Much of the result has little prospective use outside of the domain of warfare."

Describing scientific progress in peacetime as a relatively orderly process in which research workers benefit from a continual interchange of knowledge, Dr. Jewett pointed out how the advent of war interrupts this process. stimulates certain fields of research at the expense of others, and prevents the dissemination of scientific information.

"When war comes," Dr. Jewett said, "certain sectors of science and certain technological applications take on primary importance in the program of mass destruction or defense against it, and other sectors are for the time being of little or no importance in man's struggle to survive and conquer. Re-



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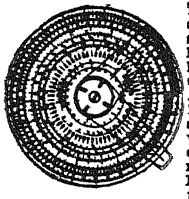

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were prepared before the war, without the slightest thought of sale to professionals. Came the war. Hundreds of new optical industries sprang up. Fewer amateurs found time to make telescopes yet sales of these books increased! Investigation of sales revealed that the new industries were buying them by the hundreds

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search work in these latter fields tends to dry up and cease. General training for research and broad technology diminishes rapidly and highly specialized training for immediate productivity in new instruments and instrumentalities of war takes its place

"Even in those sectors which are indicated fields for warfare, fundamental scientific research soon becomes a rarity —the tempo of war is too great to admit of squadering manpower on an adventure of such long duration and so uncertain of results that it can not be usefully employed in the current struggle.

"Further, since real training in science and technology equips a man for many things outside his particular specialty, there is a tremendous pressure to transfer men from fields of lesser to those of higher promise in the art of killing. Likewise, the conditions which are mandatory for general scientific progress disappear. There is no longer any intercourse between the scientific worlds of the warring nations and a minimum even of free interchange within the nation itself. Every one is bound by rigid rules of military secrecy and, despite heroic efforts to disseminate helpful information without breaking these rules, a large amount of work has to be done in essential watertight compartments and in ignorance of much that would be helpful.

"A war effort as vast as the present one, if long continued, accentuates all these tendencies and dislocations immeasurably The whole thing is an undertaking which destroys progress in basic scientific knowledge and in the application of that knowledge to the general betterment of society. In some directions there will be astounding technological development while in others there will be little or none. Even where development has been great, much of it is likely to be of little use to society since it is concerned exclusively with items of warfare which have no normal counterpart in peacetime needs."

Among the fields where scientific progress has benefitted from a war-occasioned stimulus, Dr. Jewett mentioned aeronautics, electronics, the development of substitute materials, and medicine.

"By far the greatest technological post-war problems have to do with man himself in solving his adequate adaptation of technical knowledge to mass utilization for beneficent purposes," Dr. Jewett said.

POST-WAR WOOD

Demands Will be Greatly Increased

THE SOUTH will be called on to supply about one half of the nation's future timber requirements, now estimated at 21 billion cubic feet, according to Lyle F. Watts, chief, Forest Service, United States Department of Agriculture.

Watts says that the nation appears to be entering upon a new era of wood, with many new uses opening up in the field of chemistry and new engineering techniques enabling wood to hold its own in competition with other building materials. For the period immediately following the war, he says that reconstruction requirements abroad hold promise of greatly increased export markets.

If these needs were to be supplied, Watts says, it would be necessary to double the annual growth in the southern states, since even before the forests were subjected to stepped-up wartime cutting annual growth was estimated at 5 6 billion cubic feet, or only about half the post-war output to be expected of them. Sawtimber drain is already almost twice current annual growth. In this doubling of the productivity of its forests, he adds, lies the chief hope for much of the industrial expansion now "so eagerly sought by the South."

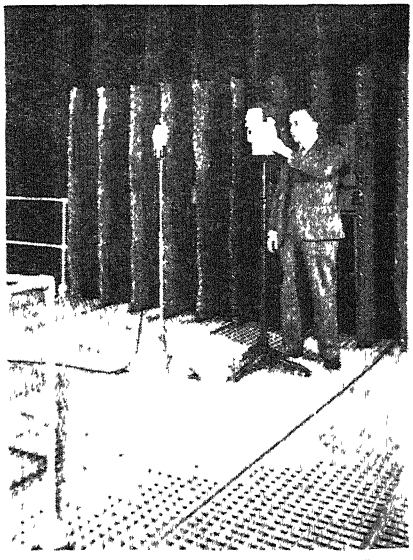
The chief forester advocates public regulation of cutting and other practices on privately owned forest land as indispensable, if prospective post-war production goals were to be met The type of regulation urged by the Forest Service would provide for direct Federal action only when and where a state failed to enact and enforce suitable legislation From the standpoint of sheer self-interest, Mr. Watts points out, the South should welcome this aid and stimulus

QUIET, PLEASE

Might be the Slogan of a Free Field Sound Room

THE "quietest room in the world," which was built to make possible accurate measurements of sound and performance of radio and sound equipment, was described in a paper recently presented by Dr. Harry F. Olson, of the RCA Laboratories, before the Society of Motion Picture Engineers.

Looking more like a weird and fantastic stage setting for a psychological



Sound-reflection effects of a speaker's face and head when close to the microphone are checked, in the RCA free field sound room, with this robot. Musical tones, produced by an audio oscillator, issue from the "mouth" and are trapped by lined walls and baffles

drama than the scientific workshop that it really is, this "free field sound room" is used to provide the necessary conditions for making accurate acoustic measurements required in the development of microphones, loudspeakers, and other electro-acoustic equipment.

Standing on a grilled platform, midway between an unseen floor and an unseen ceiling, looking into depths of shadow on all sides and above and below, a visitor in this strange room might for the first time hear his own voice—or any other sound—as it really is, without the distortion ordinarily caused by reflected sound and by the intrusion of direct sound from other sources.

But if this visitor—perhaps a nerve-wracked refugee from the screech of subway trains and taxi brakes and the rest of the bang and clatter of city life—should care more for quiet than even the true sound of his own voice, he would experience a silence more ominous and oppressive than the shadows brooding among the deep baffles of sound-absorbing material lining the room, a silence in which he would hear the small sounds produced within his ears by the living processes of his own body.

Chiefly responsible for the shadows as well as the quietness are baffles which extend into the room from all of its surfaces. They consist of strips of Ozite, one inch thick and alternately seven feet deep and four feet deep, placed at right angles to the walls, ceiling, and floor, and spaced one foot apart. Behind these are sheets of one-inch Ozite placed parallel to and one foot removed from the walls, ceiling, and floor. The function of these baffles may be visualized as that of sound traps, for sound waves entering them are annihilated, and none escape but those which are too long for the depths of the baffles

FARM FACTORIES

Forseen for the Post-War Future

THE FARMER of the post-war period will be an industrialist as well as a producer of raw materials for industrial purposes, D. Howard Doane, of St Louis, predicts in *Farm Journal*.

Doane, the nation's leading professional manager of farms, with 350,000 acres under his supervision, says: "The next and biggest step in agriculture is establishment of fixed and movable processing plants, handling agricultural products grown near by, which will extract, compress, dehydrate, refrigerate, concentrate, and fabricate these farm commodities."

Products which offer the best possibilities for processing in rural industries are those which are bulky, full of water, or perishable: or those where a large number of handlers have crowded between producer and consumer. Some of the processing will be done on individual farms, some by farmers' cooperatives, some by private companies, including rural branches of city industries.

Doane calls the new program "vertical diversification," explaining this to mean that, instead of raising many kinds of crops, known as "horizontal diversification," the farmer will concentrate on his most profitable crop, and make it as nearly ready for the consumer as he can.

GADGETS MUST WAIT

Volume Goods Will be First in Post-War Period

FEW OF the startling mechanical "gadgets" born of war's speeded-up research will be coming off production lines in the immediate post-war period, states Dr. H. E. Fritz, research director of B. F. Goodrich Company, because employment needs will demand big-volume production of those goods for which industry already "has the tools."

To emphasize the magnitude of the problem the nation will face in maintaining jobs when war work is finished, Dr. Fritz points out that 1944's estimated production of war goods alone—$80,000,000,000—will be the equivalent in dollars of "200 Panama canals, so you see that during 1944 we will be producing the equivalent of a little better than one Panama canal every two days."

The need for speed and volume in "compensating" peace-goods production will be so great, he adds, that there will be a considerable period after the end of the war before many of the war-born mechanical innovations can reach the market.

Among things "we may expect" in the post-emergency years Fritz lists. A cloth-like material which needs no weaving, made from mixtures of natural and synthetic fibers by a paper-making technique; non-shatterable glass and glass fibers with tensile strength of 3,500,000 pounds per square inch, 10 times that of malleable steel; a chemical which provides a sort of invisible raincoat for anything that is dipped in it, without there being any visible film on the fabric, and hundreds of new rubbers and rubber-like materials "performing unique and unexpected jobs and made from wheat, corn, garbage, soybeans, coal, petroleum, limestone,

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milk, sweet potatoes, and even salt."

"In order to meet consumer needs and furnish jobs, our factories for some time after peace comes will turn out models not greatly different from the pre-war ones, using old patterns, jigs, and dies," he says. "Once the 'old' models are in production and people are back at work on peacetime jobs, the psychological hunger to purchase will begin to taper off. That will be the time to begin offering the new gadgets and things to keep the process going. At this point new marvels of science will begin to appear.

"Some research people may feel this is a step backward, but we must recognize that it is far more important to keep unemployment to a minimum than it is to furnish the public with new gadgets that will take time to develop, let alone get into volume production. After all, many of the pre-war things were pretty good, too."

Dr. Fritz describes as the "paratroopers of industry" America's research chemists and physicists who have wrested world leadership in research and development from Germany. "Many comparatively new American machines and instruments," he says, "are proving their superiority in the fiery crucible of war in spite of the fact that the enemy for many years has devoted much time and skill to devising instruments of destruction while Yankee ingenuity was concentrating on better standards of living, not standards of killing."

FILTER OF RUBBER

Made by Exploding Trapped Air

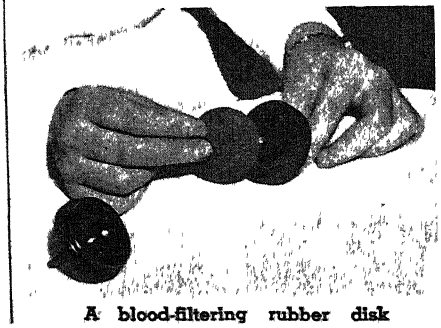
THOUSANDS of lives are now being saved because 18 years ago the laboratories of United States Rubber Company made a leaky raincoat. So states Herbert E Smith, president, in telling of the development of Multipore, a filter material with as many as 6400 holes to the square inch, now in use in the preparation and administration of blood plasma.

"This versatile material," Mr. Smith says, "is also filtering fruit juices for shipment to combat areas It is serving in the purification of insulin, aiding in the production of magnesium, increasing the output of coal and steel, and speeding up the production of four-engine bombers.

"Multipore may be traced back to the day 18 years ago when our laboratories were pioneering in the use of natural rubber latex for waterproofing raincoat fabric," Mr. Smith continues. "Pinholes, almost microscopic in size, mysteriously appeared after the fabric had been heated in the drier. These holes were found to be the result of small explosions. Pockets of air were being trapped within the mesh of the fabric, and when they were expanded by the heat they exploded through the films of latex that had been spread on the fabric.

"A remedy was immediately found, before the raincoats went into production, but our scientists didn't stop there They took a fresh start in the opposite direction to see just how many holes they could shoot through a square inch of latex film. They succeeded in blowing as many as 6400 holes to the square inch, in sheets up to 42 inches wide and 20 yards long—and created Multipore"

These filter screens are made of either hard rubber or soft, and may be compounded to resist abrasion, high temperatures, alkaline and acid solutions, and certain oils and greases, it is stated Since they are made only from natural rubber latex of the Hevea tree, now one of the most critical of all materials, the filters can be applied only to the most important products.

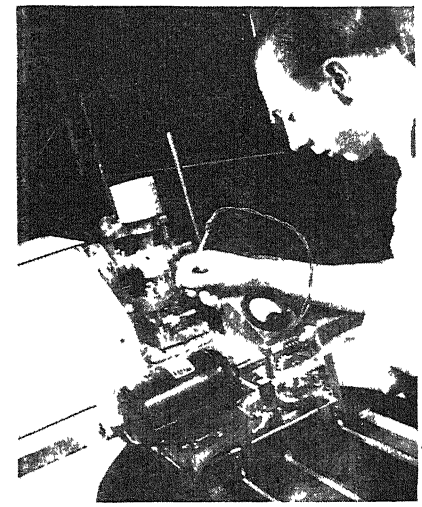


A blood-filtering rubber disk

GLASS JEWELS

Produced in Quantities for Use in Instruments

TINY sapphires threatened to hold up production of instruments at the beginning of the war. An absolutely essential part of our vast airplane program, millions of electrical instruments awaited a substitute for the jewels formerly supplied from factories of Switzerland, blockaded by the Axis. According to Westinghouse engineers, a way has been found to make these vital instrument jewels of glass. At first they were made slowly, by hand, one at a time. At best, a worker could make about 1200 a day, of which many were imperfect.



Machine for making glass jewels

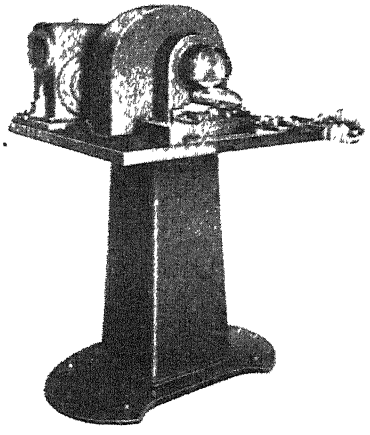
Now they are turned out by automatic machines at the rate of 3500 per day. Not only that, but one operator can tend two machines that produce almost no poor jewels. This glass-jewel development wiped out a threatened war-production bottleneck and produced a better product. For many types of instruments, engineers now prefer the jewels of glass to those of sapphire.

New Products

MARKING MACHINE

A NEW rotary marking machine for high-speed production marking of machine tool parts that can be rolled meets all safety requirements and does difficult marking formerly accomplished only with large special equipment

Driving power is furnished by a 1½ horsepower-gear reduction motor with extended shaft on which is mounted the marking roll. The oversized shaft is supported by two heavy pillar blocks



For high-speed production marking

with heavy roller or ball bearings to support the marking strain Switch box on the machine controls the motor and a transparent Lucite removable guard covers the marking roll for safety.

The wedge type cradle rolls are controlled by a hand lever that brings the work into marking position against the continuous rotation of the marking roll.

SLOW-HITTING HAMMERS

TWO SIZES of a completely new line of slow-hitting aircraft riveting hammers are now in production. These new hammers are notable for their power, control, smooth operation, and ease of handling, and have a number of features such as a two-finger trigger, a metered air throttle valve, an improved offset handle, good balance, and compact design. Women riveters, especially, find that they can operate these Forss hammers more easily, and do more and better work with less fatigue.

COMBINATION DUST COLLECTOR

PORTABLE and self-contained is a new dust collector of the cyclone-filter type for exhausting dust- and dirt-laden air from most types of medium-heavy abrasive operations, announced by Aget-Detroit Company.

The new unit contains a multiple-blade fan direct-driven by a continuous duty motor, a removable spun-glass filter, and a cyclone type separator. This combination allows the cleaned air to re-circulate into the working space for big reductions in heating losses.

Continuous duty operation of the new unit on medium-heavy dust collecting operations, without frequent changing of the filter, is possible because of the high efficiency of the cyclone separator which removes most of the dust and dirt before the cleaned air is returned to the working space through the filter.

Recommended for collecting dust from production grinding operations on big-wheel surface grinders as well as medium-sized double-end grinders, disks, cut-offs, emery and belt sanders, the new unit is said to be the most compact dust collector of the cyclone separator type available

A glass jar stores the collected dust; glass is employed so that it can be easily determined when it is full and so that it need never be removed until it is full. Doors on both sides of the cabinet permit ready access to the dust storage.

VERNIER GAGE BLOCKS

GAGE blocks, whether in small toolmaker sets or large complete sets of over eighty blocks, have heretofore been limited to combinations which could be made in increments of one ten-thousandth of an inch. Now the new DoALL vernier gage simply and effectively extends the range of combinations of sizes which can be made with any set of gage blocks by enabling combinations to be made in steps of ten micro-inches and to the same degree of accuracy as provided by precision gage blocks.

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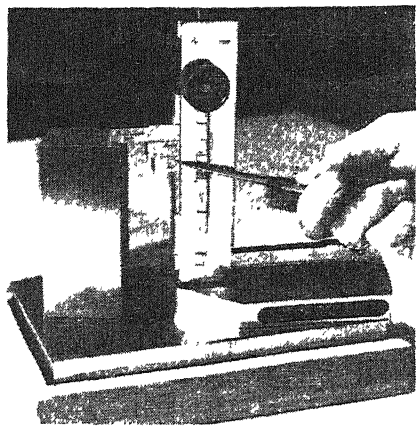


A taper is the secret

with the vernier gage can be quickly set up to produce practically all types of snap gages, height gages, and depth gages to millionth-inch accuracy at a fraction of the cost of a special gage. The gage, while of the highest precision, is extremely simple in construction. It consists of two gage blocks having a precision taper on their mating faces. When the taper faces of two blocks are wrung together with their taper index marks coinciding, the blocks form a gage block whose height is 0.700 inch. One block is graduated into ten equal parts between the index graduations. By sliding this block to the right, the height of the vernier gage is increased ten millionths of an inch for each graduation because of the taper. Sliding the block to the left, the height of the vernier gage is decreased ten millionths of an inch for each graduation. The gage has a total range of one ten-thousandth of an inch plus or minus, thereby enabling dimensions to be made in increments of ten millionths above or below any dimension which can now be made with a standard set of precision gage blocks.

PAYROLL CALCULATOR

OVERTIME, as well as straight-time payroll calculations, can be figured in a jiffy with a new and improved model payroll calculator now being manufactured by the Berger-Brickner Company. Forty hours plus overtime are calculated in one operation on one side of the device for firms that require total pay check only. The reverse side is used for figuring straight time and overtime as separate items.

All hourly rates of pay from $.40 to $1.74, with a half cent spread between rates, and time periods up to 80 hours, with divisions of tenths and quarters of an hour, are covered by this inexpensive calculator.

FLOW GAGE

ACTUATION of the indicating dial of a new continuously indicating flow gage is brought about by the kinetic energy of the fluid flowing through the gage. Briefly described, its mechanism consists of an indicating dial constructed as an impeller, the rotary movement of which is resisted by a precision torsion bar. The Flogage, as the instrument has been named, is insensitive to changes in fluid viscosity, fluid temperature, or fluid pressure It is accurate to within a fraction of 1 percent and can be constructed to withstand any internal pressure without affecting its accuracy.

Design and construction of the unit are adaptable to any flow indicating problem Provision is made for fittings, top and bottom, which, together with a bracket that is cast en-unit with the center structure, facilitate installation

MULTIGRAPH TYPE

PRINTING that looks as if it were produced by letter-press can now be done on a Multigraph machine. The type is cast in bars, similar to Linotype, each line in one unit. Sharp, new, clean-cut bars are supplied in typewriter type or "print-shop" type faces and sizes, and the multigraph job is done by regular office help.

It's a matter of minutes only to transfer the type lines from the subdivided mailing box in which it is received to the Multigraph drum, ready to run The type may be kept on hand in special boxes for repeat usage if desired, or may be returned for metal credit.

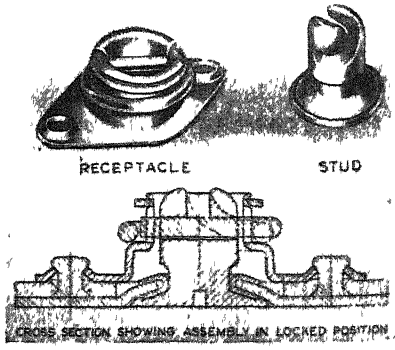
CUTTING OIL COMPOUND

FOR USE in cutting hard high-speed tool steels, chrome molybdenum, and the new National Emergency Alloys, a new cutting oil is a mixture of animals oils and other chemical ingredients. It is claimed by the manufacturers to increase tool life from two to six times before regrinding is necessary; to increase production from 25 to 100 percent by allowing a much higher cutting speed; to reduce over-heating; and to give a finish far superior to any other cutting oil compounds.

This new cutting oil was developed in the shops of the Fearless Tool Company for tapping chrome molybdenum nuts and other parts. It should prove of interest to those manufacturers who are having difficulties in tapping. It is particularly recommended for tapping operations where difficulties are experienced in getting clean threads or where higher cutting speeds are needed

SPRING-LOCK AIRPLANE FASTENER

A NEW spring-lock fastener is a lightweight unit of extremely rugged construction, particularly suited for holding the engine cowlings of high-speed war planes. In addition to its important uses on airplanes, this fastener is suited to



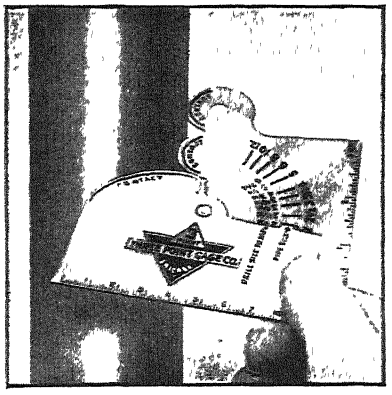
Vibration-proof lock fastener

many post-war commercial applications, such as access plates on farm machinery, panels on motor trucks, home heating units, radio equipment—any point where a quick-acting, vibration-proof, non-rattling fastening is needed

PIPE GAGE

A POCKET sized, three-point pipe gage for instantaneous measurement of all sizes of pipe from ⅛ inch to 12 inches consists of two pivoted steel plates with edges curved at three points for contact with the pipe to be measured, together with a scale which automatically registers not only the pipe size in terms of inside diameter but the drill size for tapping.

By placing the two fixed contact points of one plate against the outer



Pocket-sized pipe gage

contour of the pipe and sliding the second or moveable plate until it makes the third contact, the marker on the face of the gage will show accurately the size of the pipe. It is necessary to contact only a small section of the pipe contour in order to obtain a measurement.

INSULATED PINION GEARS

INSULATING pinion gears from shafting by means of a bushing of rubber placed directly between gear and shaft to stop transmission of noise, shock, and vibration, is a development just announced by Bushings, Inc. The new process, which is both simple and foolproof, has important advantages of extreme low cost and elimination of two machining operations normally required for milling keyways or flats.

No special preparation of shafting or gear is demanded by the new process. The synthetic (or rubber), after it is in position, provides a mechanical bond with the bore of the gear and the surface of the shafting of sufficient strength to transmit the required torque.

FLUXED SOLDER

A NEW type of wire solder, which contains flux in longitudinal grooves on the surface rather than in the conventional core, has just been placed on the market.

The new material, called Fluxrite and put out by National Lead Company, is said to overcome an inherent disadvantage of regular cored solders which supply flux and solder to the surface simultaneously. Since the flux in the new product is outside rather than in-

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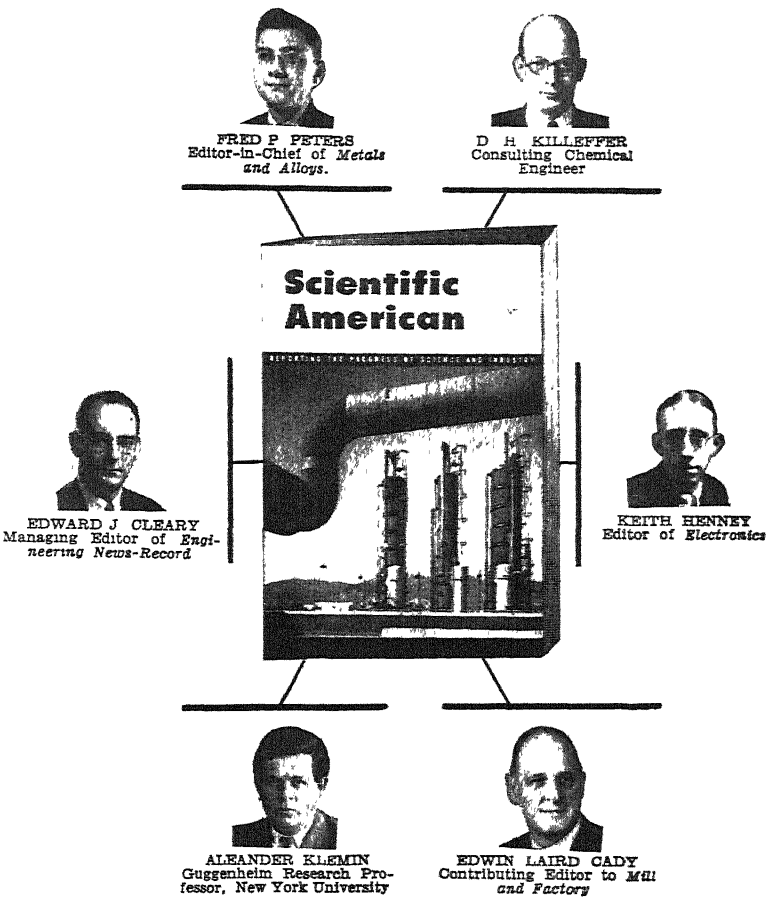

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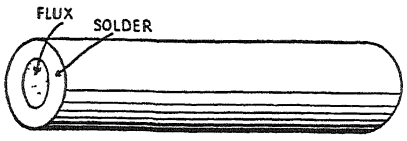
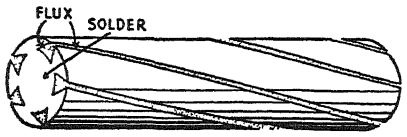


CONVENTIONAL FLUX-CORE WIRE SOLDER



NEW-TYPE OF WIRE SOLDER WITH FLUX IN GROOVES

The old and the new

side, it liquefies and flows onto the work *before* the solder melts. This insures thorough and complete fluxing and results in stronger and better soldered joints.

This product, which contains a recently developed special flux, comes in the same diameters as regular cored solder. It is available in two compositions designated as Red Stripe and Green Stripe. These designations refer to the color of the flux which has been specially dyed in each case for easy identification.

UNIVERSAL CENTRIFUGAL CLUTCH

A NEW type of automatically engaging and self-disengaging centrifugal clutch can serve either as a coupling between shafts or as a driving pulley or gear in a transmission, as well as a starting cushion between power units and driven mechanisms.

This new unit, which is known as the "Torkontrol," consists of a partially filled oil chamber fitted with a freely rotating hub, which carries a series of movable wedge-shaped flyweights. As the hub revolves these weights fly outwardly and engage the internal rims of the outer case, binding the hub and shell into a functionally solid pulley or coupling.

The unit works equally well in either direction and is "set" to engage or release at a given speed, and to slip in case of overload.

The manufacturer, Amalgamated Engineering and Research Corporation, claims that this unit permits the use of smaller engines or motors which start without load, gives smooth cushioned application of power and straight-line acceleration with resulting savings in operating cost.

PLASTICS CLEANER

REMOVAL of gummed paper from plastic glass sheets and formed parts is expedited by the use of a new chemical compound, Turco Plasti-Clean, which has been formulated for this special job.

Heretofore, aircraft factories have experienced considerable difficulty in removing the tightly glued masking paper which covers the sheets and formed parts when they are delivered from the manufacturer. If this glued paper is allowed to remain on the plastic for any length of time, or is exposed to heat or sunlight, the paper vulcanizes to the plastic glass and virtually becomes a part of it. Naphtha solvents when used for this purpose often cause "crazing."

Removal of the masking paper with Turco Plasti-Clean, however, is a safe and thorough method, according to the manufacturer. Plastic sheets and formed parts are simply soaked in a tank full of the compound until the gummed paper is loosened, when it is easily peeled off. Turco Plasti-Clean is recommended for Plexiglas, Lucite, Plastacele, Acetate, Pyralin, and all transparent plastic glasses.

LEAD PLATING

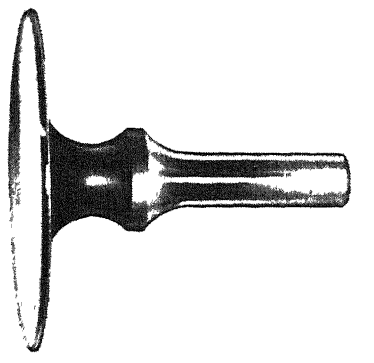
FOR THE protection of iron and steel against corrosion and to obtain a corrosion-resisting coating on non-ferrous metals, electro-deposited lead has been used to a limited extent for many years. The use of lead coatings as a substitute for more critical metals is increasing and may assume considerable proportions.

Concentrated Protecto Lead Solution, which has been sold by the Hanson-Van Winkle-Munning Company for many years, is now substantially improved by recent changes in the formula. To prepare a working solution, simply add three parts of water to one part of concentrate. The resulting solution is for general purposes, plating at low to medium current densities. The plating range is from 5 to 15 amperes per square foot.

Another modern electrolyte is the B-H Lead Solution, which is not concentrated but is used for lead plating as prepared. It is designed especially for lead plating bearing surfaces, and is being used by large aircraft motor manufacturers. This solution produces deposits with the proper micro-structure for subsequent indium plating and heat treatment.

RIVET SET

AN OVERSIZED rivet set 2½ inches in diameter that is said to eliminate the danger of damaging thin skins is being



Oversized, polished rivet set

manufactured by the Aero Tool Company. Even in the hands of unskilled labor, the extra large face and light weight of this set reduce rejects and speed flush riveting operations. A mirror-like, ultra-smooth finish on the crown surface protects thin skins from dents and abrasions while riveting.

Current Bulletin Briefs

Conducted by

K. M CANAVAN

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

POST-WAR PLANNING NOW is a compilation of interviews with key manufacturing executives and government officials throughout industrial America It presents a summary of American industry's blueprints for the future. *New York Journal of Commerce, 63 Park Row, New York, New York.—25 cents*

A S.T.M. STANDARDS ON PLASTICS is a 445-page compilation presenting 85 specifications, tests, and definitions. These cover the general field of present-day plastics and should be of interest to all concerned with the manufacture or use of such materials. *American Society for Testing Materials, 260 South Broad Street, Philadelphia 2, Pennsylvania.—$2.00*

BETTER CROPS is an eight-page folder describing the uses of Hormo-Fert—a fertilizer with plant hormones added—and the results which have been obtained under test conditions. *Weil's Fertilizer Works, Goldsboro, North Carolina.—Gratis.*

MAINTENANCE ARC WELDING is a 234-page illustrated book designed as a guide and reference covering one of the most common and useful fields to which modern arc welding is applied. The information will be found particularly useful in keeping machinery and plants in operation despite shortages of material and equipment. *The James F. Lincoln Arc Welding Foundation, P. O. Box 5728, Cleveland, Ohio.—50 cents.*

RESEARCH IN STEATITE PORCELAINS is a 48-page engineering report covering a study of the firing behavior of the clino-enstatite field employing talc minerals, magnesia, and silica, plus a study of the talc minerals in steatite bodies. *Engineering Experiment Station, Ohio State University, Columbus 10, Ohio.—50 cents.*

WAGE INCENTIVES IN WARTIME is a 48-page discussion of this method of increasing production without extra manpower. The text is planned as a guide to management, and covers the whole subject clearly yet concisely. *Consolidated Management Consultants, 521 Fifth Avenue, New York 17, New York.—Gratis.*

TOP PERFORMANCE IN STEEL CUTTING is a 16-page vest-pocket sized guide to the characteristics of different grades of carbides designed for steel cutting, selection of proper rake and relief angles, size of radius, and so on. Attention is also given to machine requirements, speeds and feeds, design and grinding of chip breakers, and the problem of coolants. Trouble-shooting suggestions are included. Manual GT-166. *Carboloy Company, Inc, Detroit 32, Michigan.—Gratis.*

SPECIAL TOOL HANDBOOK is a 60-page, flexible-bound catalog which includes illustrations of high-speed-steel cutting tools, together with specifications. It is designed to fill a need for a basis upon which to select special tools for special requirements. *U. S. Tool and Manufacturing Company, 6906 Kingsley, Dearborn, Michigan.—Gratis*

SEVENTY-FIFTH PENN METAL YEAR is a 28-page anniversary booklet tracing the history of one metal producing organization through its formative years up to the present day. *Penn Metal Corporation of Pennsylvania, Oregon Avenue and Swanson Street, Philadelphia, Pennsylvania.—Gratis.*

PNEUMIX in action is a 24-page pamphlet describing a number of types of air-motored agitators and their uses in industry. Two features claimed for these agitators are the elimination of fire and explosion hazards and the variable speeds obtainable through air control. *Eclipse Air Brush Company, Inc., 400 Park Avenue, Newark 7, New Jersey.—Gratis.*

CLEANERS FOR METALS is a bulletin dealing with the selection and use of cleaners made from water solutions for the removal of oils, machining chips, abrasives, and various dirts incident to metal producing and fabricating. A total of 19 special cleaners is described. Also included is a discussion of metal-cleaning processes in general. Bulletin C-105. *Hanson-Van Winkle-Munning Company, Matawan, New Jersey.—Gratis.*

MATERIAL HANDLING EQUIPMENT is a single sheet which describes and illustrates a number of lift trucks, elevating platforms, hoisting trucks, and similar equipment for various types of material handling *Lyon-Raymond Corporation, 1402 Madison Street, Greene, New York.—Gratis.*

WOMEN A.W.O.L. is a 32-page pocket sized booklet which discusses the problem of women absenteeism in industry, and of the incentives which can be offered to reduce this important factor to a minimum. *National Foremen's Institute, Inc., Deep River, Connecticut. Sample copy gratis, quantity rates on application.*

THE IMPROVEMENT OF METALS BY FORGING is a 36-page reference data book which, through the use of charts, photographs, and detailed drawings, presents factual working information drawn from years of practical experience. Content covers types of forgings, forging design principles and processes, the metallurgy of forging, and metal specifications and physical properties. *The Steel Improvement and Forge Company, 734 Union Commerce Building, Cleveland, Ohio.—Gratis. Request this booklet on your business letterhead.*

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Telescoptics

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Conducted by ALBERT G INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

OF THE THREE ways to make optical flats, briefly outlined by Porter in "Amateur Telescope Making," page 57, the first, or three-disk method, is described at greater length by Selby in "Amateur Telescope Making—Advanced;" the second, or Ritchey, method using concave mirror and knife-edge accessories is described by Pierce and Ritchey in "A.T.M.," page 241; but the third, or borrow-a-master-flat method, is not covered in either book.

"Why keep this third method in the optical doghouse?" a few have asked, "What do you hold against it?" The method is excellent—provided the user can borrow the necessary master flat. John W. Erdman, 50 Howland Ave., North Hackensack, N. J., an amateur astronomer and telescope maker who has worked several years as a professional precision optician, now offers the rest of the fraternity the full recipe for method 3. He writes:

First, procure a flat as your testing piece—by the "beg, borrow, or steal" method if necessary. Even one which may not be absolutely flat will be of great help, but in such case some other final test would be necessary.

Use Pyrex; it is more dependable for maintaining surface than plate glass, is less likely to spring out of shape if the glass is to be blocked on either wood or metal, and is less affected by heat generated from polishing.

Choose the face having the lesser diameter for the optical flat side. The taper then will tend to prevent, rather than facilitate, accidentally dropping the disk when the hands are wet. Hence, grind the larger face first. Proceed on that side with the usual grades of emery, grinding against any suitable flat surface. A grinding tool slightly larger than the disk, roughly one tenth larger, may be used to advantage, as will be shown later. A tool made with facets is a great help in eliminating zones. Those having a lathe can make a good grinder by cutting a series of concentric rings in a metal tool.

The back (larger) face may be polished quickly and needs no figuring. All we require is clean polish and reasonable flatness. A wavy or irregular surface might, however, introduce incorrect interpretations of the interference fringes on the other side.

Now for the all-important surface on the smaller side.

Some form of monochromatic light must be provided. A fluorescent lamp may serve in the early stages of polishing, but is not suitable for the final testing.

The grinding of the second face proceeds as before, except that with each grind of emery the surface must be brought closer to flatness, testing with a straightedge and frequently inverting the tool, whether it be glass or metal, to maintain this flatness. If a straightedge is not available, the borrowed test flat will serve if moistened (for this there is nothing better than the tongue) and pressed into close contact with the surface. The moisture spreading between the glasses will show even minute deviations. The straightedge can be checked by carefully placing it on the test flat.

In the final stage of grinding, great care is necessary in bringing the surface as nearly flat as possible. Here moisture from the breath is sufficient in the test against the master flat. Better still is testing the fine grind by interference. If this grind is brought to a satiny, glossy finish, fringes may be seen by placing the two glasses in contact and viewing them at 18" to 24" from a very low and slanting angle. A fluorescent light will not serve for this test. While the view from this angle is not exactly correct, it is close enough at this stage. Move the test glass off center and study the fringes clear to the edge. Often they appear quite straight over most of the ground glass, but break off toward the edge. Continue grinding until this condition is eliminated.

Close attention must be paid to the stroke in grinding, so that if small errors are to be corrected, the least amount of effort will be required. The same type of strokes are used as in producing a spherical surface. A flat must be considered, both in grinding and in polishing, as a spherical surface. If it appears concave, it is treated exactly as a concave surface which is too deep. If it appears convex, it is treated as a convex surface which is too steep.

The work may have to be turned from bottom to top several times, before completing the grind. Never, however, attempt to polish until the interference fringes show that the surface is quite flat, for it is much simpler to grind out imperfections than to polish them out. Watch particularly for concave zones near the center, and for turned down edge. These cannot be tolerated. One wave regular curvature is acceptable; ½ wave, or 1 ring, is still better. If the rougher grinds were kept reasonably flat, it should not be difficult to bring the fine grind this close. With the borrowed master flat as guide, making small changes in stroke, this can be attained without too much difficulty. Again it must be stressed, do not polish until the fringes show not more than two rings of regular curvature.

The first job connected with polishing is making a lap. I sometimes have found advantage in using a lap of slightly larger diameter than the disk (approximately ½" larger for 6" work). If a slightly oversized grinding tool is used, it will do nicely in making the lap. One advantage in polished flat work is that many types of materials, only reasonably flat, will serve as backing for the lap. Thick plate glass, properly supported, will do. Often, in making a flat, a full-sized lap can be used in polishing on top, and the oversized lap on the bottom when the disk is to be inverted. Here a great deal is left to the worker and to the intricacies of each particular job.

Use a pitch somewhat on the hard side, but not too hard. Good work can be produced on pitch of varying hardness, but nothing but new difficulties will arise from using pitch harder than necessary. Keeping full contact with the glass is absolutely necessary. Pitch that is too hard often makes this difficult.

Build a small dam around the warm tool (ordinary masking tape serves nicely for this) and pour on a thin layer of pitch. A little less than ¼" is about right for 6" work. As soon as possible, remove the dam with short, quick pulls. Raised edges of the pitch may be chopped off with a razor blade.

When the pitch begins to harden, yet is still quite warm, smear on rouge having a consistency on the pasty side, and carefully rub the lap to shape with the fine-ground flat. Rub lightly at first, and add pressure as the lap takes shape, using short strokes and small circles. Do not allow too much heat to get into the glass; remove it from time to time to cool. Continue this until the pitch is fairly cool, having assured yourself that the lap has come to full contact all over.

With a little warmth still left in the lap, clean off all the rouge and scrape small channels into the pitch with the corner of a razor blade. They should be cut clean across the lap with one quick stroke of the hand, and about 1/32" deep. Five or six strokes in one direction are crossed with as many in one or two directions, until a reasonably regular criss-cross pattern is achieved. It is not, however, necessary to space these scratches carefully, but leave no one zone untouched.

New contact must now be made with the lap, until an even, steady pull with the stroke is felt.

When the lap is fully cool, actual polishing may begin. Within a few minutes, the worker can note whether his flat has begun to polish with reasonable evenness. A spotty condition in the polish will indicate that the lap is out of contact, and re-heating is necessary. The easiest method to reheat a lap is to invert it in a pan of warm water for a minute or two. Cold pressing between spells is not recommended with this type of lap. Just warm it a little before the start.

If an oversized lap is being used, it should remain on the bottom, even if the first test shows that the work is

concave. Simply proceed with short strokes for a polishing spell, and study with the test piece what changes occur If this first test indicates that the work is convex, proceed with longer strokes. These strokes must vary with your own judgment, while watching the response with the borrowed flat. There is no need for waiting long to test at this stage, since small variations are not yet important It is well, however, to keep in mind that heat generated from polishing will give you a reading on the convex side of the true condition. For example, if the first reading should indicate absolute flatness, the work will nearly always be at least one ring concave. If it appeared at first a little concave, it will ultimately cool off even more so. At this point we are concerned mostly with an even polish, keeping the surface as flat as possible and free from zones. If a machine is used, a slow, steady stroke should be selected.

The scratches on the lap should never be permitted to close in entirely but should be removed as soon as the worker sees that they are becoming filled. They are purposely made shallow, so that they may be changed or modified to meet the irregularities or any conditions which may develop in the surface of the flat. For example, if a small hole should begin to appear near the center, new scratches can be cut in the lap at the corresponding spot. As this hole begins to disappear, these scratches need not be renewed, and will soon flow back into the lap. If the edge of the glass appears to be turned up, the scratches may be deepened more in the central section of the lap and temporarily not renewed at the edge. All normal deviations may be dealt with in this manner. However, no large zone should ever be left without any scratches at all, else serious irregularities may develop. Generally, when certain corrective scratches are made, enough former ones remain in other zones to suffice In this fashion I have produced several flats, free from all irregularities, with a single oversized lap used entirely on the bottom.

Do not be afraid that the oversized lap will develop a turned edge. Reasonable care with the stroke will prevent this In fact, an undersized lap will more quickly result in a turned-up edge. In mirror making, where infinitesimal deviations of radius have no importance, a turned-up edge is easily dealt with: while in flat making, the radius being infinity and necessarily kept so, treating a turned-up edge will often produce an undesired radius in the work. Frequently a finished flat, quite satisfactory as far as edge condition is concerned, will show from the fringe reading a faint blur in the outer 1/64". Since this amount will be taken off with a bevel, it should not concern the worker, as this sharp edge must be removed at any rate.

When an equi-sized lap is used throughout, the worker will naturally polish face up or face down, as the curve of his surface demands. Do not always, when it is found that a fairly long stroke has changed the reading from concave to convex, or vice versa, be too eager to invert the work, but try first a shorter stroke.

As in grinding, close attention must be paid to the stroke used, in order that small changes can readily be dealt with by the necessary alteration in stroke.

As each job has new characteristics, these must be dealt with through the ingenuity of the worker. Sometimes when a hole persists in the central zone, and continual renewal of the scratches fails to correct it, a hole may be cut in the center of the lap, beginning with a small one and, if necessary, enlarging it If a turned edge should persist, cut small scallops around the edge of the lap.

By following these methods the worker should have no difficulty in making a good flat; especially through bringing the fine grind as nearly flat as possible and keeping it that way throughout

It is well to move slowly until you are sure of yourself Usually, time is saved in the end.

In the final stages allow from 20 to 40 minutes for cooling—depending upon the length of the polishing spell—for a good test.

A flat can be called really good if the fringes, when separated about 1½", are straight clear to the edge. Rotate the flat and view the fringes in several directions; a minute cylindrical condition will not necessarily reveal itself from a single axis

If the flat is to be used solely as a testing piece or master flat, polishing need continue only until naked-eye evidence of the final grinding is removed. Small pits will in no way lessen its value

In making the plane side of a lens, the same procedure may be followed. Usually one ring of regular curvature is acceptable, hence such a surface is a great deal easier to produce than the master flat. Turned edges of small degree may be ignored, since the centering of the lens will remove them. Prism faces are naturally more convenient to polish on top, and an oversized lap should always be used. The lap should have a circumference equal to or slightly larger than the longest dimension of the prism face When a number of prisms or lenses are set, or blocked, into plaster in circular form, a lap of the same size may be used, and the work may be treated exactly as if it were a solid surface.

WORK-LOVING beavers are not extinct in Beaver County, Pa., about 25 miles north-west of Pittsburgh. "The Beaver County Amateur Astronomers' Association" has just been organized there, William A. Lintz, 440 Navigation St., Beaver, Pa., being the secretary. In this organization are 13 members, a way of showing that astronomers snap their fingers at superstition. N. J. Schell, of off-axis (unobstructed) and criss-cross off-axis telescope fame, also Roelof Weertman whose 12½" turret telescope has been described in this department, are members of this new group. Paul McConnell, of Beaver, is its president and Keith Shields of Fair Oaks its vice-president.

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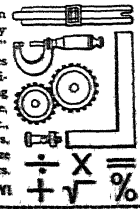

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Aviation

(*Continued from page* 168)

reaction is not practicable for commercial work, the day will come when this efficiency will be increased and the new type of power plant will be used not only for auxiliary purposes but for commercial operation as well. Some of the possibilities are very tempting. Almost any form of fuel can be used; the air screw with its complexity and noise would disappear; an efficient power plant would be attained at the very greatest altitude; and since the air screw can be dispensed with, the aircraft would be low and compact The power plant can be housed entirely within the wing. Noise would be to the rear of the pilot, vibration would be eliminated.

All this may possibly give an unduly optimistic view of the situation. No one can predict the future nor is the above anything but a brief introduction to the subject. Enough has been said, however, to indicate the importance and great possibilities of jet-propulsion flight.

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The helicopter is equipped with a 175-horsepower Warner engine cooled by a special blower. Its gross weight is 2500 pounds. The diameter of the rotor is 33 feet, and its speed is 315 revolutions per minute. The rotor is equipped with four blades, one pair of blades rotating above another pair, but both pairs rotating in the same direction Under these conditions a means for counteracting torque must be provided. Therefore there is a variable-pitch propeller at the rear of the fuselage. The tail propeller not only counteracts torque; it also acts as a rudder suitably controlled by foot pedals.

A helicopter design is far from being a matter of aerodynamics. Mechanical problems, such as the transmission, loom large Thus the motor is connected to the transmission by a special coupling which gives the effect of a universal joint and the transmission box comprises a clutch, a free-wheeling device (to come into play if the engine fails and the blades have to auto-rotate), bevel gears leading to the anti-torque propeller, and planetary gearing for reduction of speed from engine to rotor. Above the transmission box is a brake to keep the rotor from turning when the machine is on the ground in windy weather The air intake for cooling the engine is through the scoop which can be noted in the photograph.

The rotor is mounted on a universal joint which permits it to be inclined in any direction, and the direction in which the rotor is inclined is also the direction in which the airplane is propelled. Because of this universal mounting of the rotor, the fuselage remains horizontal under all flight conditions—take-off, forward flight, and landing.

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Enea Bossi (right), his son, and helicopter with four rotor blades

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COVER: Methods of fabricating and processing metals for specific purposes are much in the industrial eye today, as can be graphically gleaned from the article starting on page 199 of this issue. One of these methods—powder metallurgy—has found unusual applications in many ways. One of these is illustrated on our front cover, where a powder metallurgy press is shown producing carbide tool shapes at the rate of several hundred per hour in a plant of the Carboloy Company, Inc.

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Previews of the Industrial Horizon

By A. P. Peck

A THREAT TO INDUSTRY

RECENT agitation for grade labeling of various commodities has raised many questions in the minds of industry and consumer alike. In order that there may be no possible misunderstanding regarding this subject, a distinction must be made between grade labeling which is purely informative, and grade labeling of the compulsory type which would do away with brand names, stifle all incentive for improvement, reduce rather than improve the quality of products, lower standards to a minimum, and place a ceiling on quality rather than a floor under it

With purely *informative* labeling, whether called grade labeling or not, we have no quarrel. We *are* seriously concerned with the governmental project under which removal of all brand names from packaged goods is contemplated and which likewise contemplates the placing of a ceiling price on each grade.

That this attack on trade marks is by no means imaginary, but on the contrary quite real and imminent, is evidenced by a recent investigation in the House of Representatives of contemplated requirements with respect to labeling, production, marketing, and distribution of articles and commodities. The Congressional Record for April 10, 1943, page 3301, contains the following significant statement by Congressman Lanham of Texas, speaking on House Resolution 98:

"I should like to make this inquiry and observation. If it is contemplated that there is to be a standardization with reference to goods and the labeling of goods which would eliminate trade marks, which are a very natural and normal part of our commercial processes, it seems to me that by all means a situation of that kind should be investigated There will be created great confusion and lack of confidence on the part of the public if goods are simply to be standardized according to one pattern regardless of their origin in point of manufacture. . . .

"I see no particular objection to grades being posted on a label under a trade mark, because that would further inform the public, but to do away with trade names and to do away with trade marks would to me seem unconscionable . . ."

The consumer, as well as industry, would suffer under compulsory grade labeling Under a directive from a government board or commission or a federal grade labeling law, a federal inspector would examine the contents of a package and label the container "Grade A," "B," or "C," according to the following procedure:

After the inspection, a number of points would be given to the goods so that the grade letter—A, B, C—may be assigned. Certain features are to be examined by the government inspector. Each of these characteristics of the product will be credited and given an estimated certain number of points for scoring purposes. The total number of these points will determine the grade. For example, the product that scores from 90 to 100 points will be marked "Grade A," from 75 to 89 points, "Grade B," from 60 to 74 points, "Grade C."

Wholly apart from the obvious impossibility of having every federal inspector grade alike and even if it be assumed that such uniformity of grading were possible, the net result of such system would be to permit a product totaling, let us say, 91 credits or points, to be marked "Grade A," but another product totaling 100 points could receive no higher credit than "A." Thus, as between two competing products with a nine-point variation in grading, both would receive the same identifying characteristic of "Grade A." Both would be sold at the same price, the ceiling for Grade A. Since the poorer or 91-point product would command the maximum price, there would be no incentive for a manufacturer to raise the quality, but, on the contrary, the 99- or 100-point product would soon deteriorate to the minimum 90 or 91 requirement and in the long run the consumer would lose.

Efforts and money spent in acquiring consumer acceptance for well established trade-marked products would be wiped out and the consumer would be deprived of the symbol by which he or she had learned to recognize a tested product over an unknown product There are many other factors which from a consumer's standpoint are deplorable in the proposed grade labeling program. Space does not permit an extended discussion but it must be remembered that no system of grading can possibly take cognizance of such intangibles as, for example, the priceless ingredients of the honor and integrity of the maker whose reputation has been long established by the use of well known trade marks.

PAINT PROGRESS

PAINT is one of the industries that is going to come out of war-time production with a minimum of headaches and a maximum of business Many of headaches, in the shape of materials shortages that have been amply met by substitution (see page 205), are already past and can be converted in the future into desirable assets. Also on the plus side of the paint ledger is the fact that war-time business has stepped up almost 10 percent during 1943 over 1942, to an all-time high. This has been accomplished with very little expansion of facilities, a factor which will be decidedly favorable to the industry when output swings from military requirements to supplying a consumer demand which has been held in leash.

ITS DONE WITH OIL

RESPONDING precisely to the lightest finger touch, hydraulic power is now doing jobs on Flying Fortresses and battleships, in anti-aircraft batteries, and elsewhere, that could not be done so readily and accurately by any other means. Hydraulic power transmission—remember Pascal's Law?—originally used water but now almost universally employs oil as its working fluid. It has long been applied to heavy industrial jobs, and, just before the war, came into the public limelight in fluid-power transmissions for automobiles.

Now, however, through military applications, hydraulic power transmission has been refined to a point where it can be utilized in many ways formerly unthought of. Wherever precision of control is needed, wherever power must be transmitted to remote points, wherever smooth power flow is required, there will be found possibilities for hydraulics.

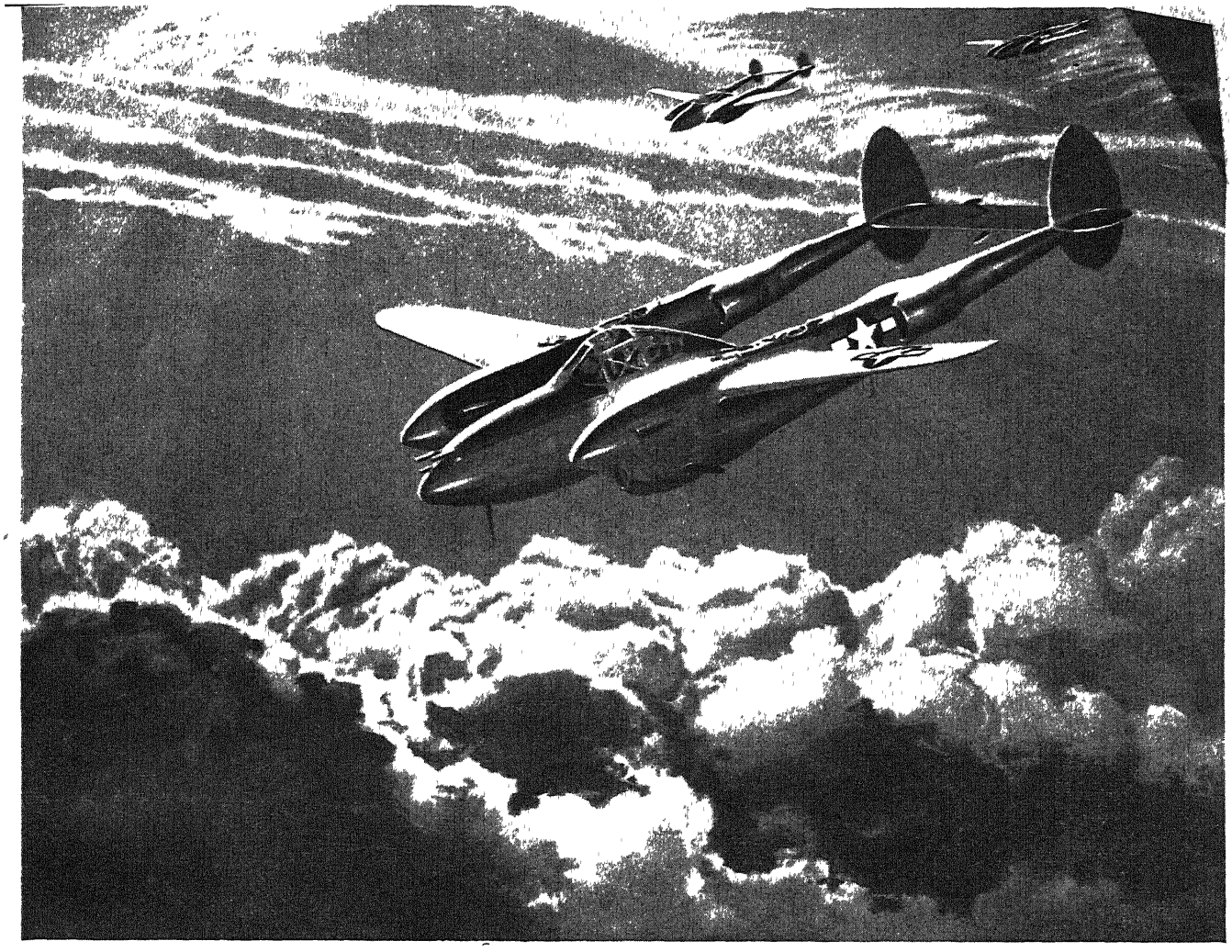
SMILES CAN HELP

INSTRUCTION sheets which accompany tools and other equipment are usually pretty dry reading, which may frequently account for the fact that they are often unread. Such instructions, no matter how essential to the efficient use of the tool or whatever, are useless unless read. At last one company has realized this fundamental fact and has not only made its instruction sheets attractive to look at and read but has added simple cartoons that instruct as they amuse.

Here is one of those little things in life than can be built up to something worthwhile by any manufacturer with imagination, no matter what type of buyer he may hope to reach.

"MIRACLE" HOMES OF THE FUTURE

DON'T put too much faith in some of the more glamorous promises of "miracle" homes for the immediate future. Materials and designs will improve considerably, but the main considerations will be conservatism and livablity. Progress will continue, but there will be no sudden burst of homes of a radically different type than we have today.



FINGER-TIP CONTROL FOR SPEED FASTER THAN SOUND

When an Army Air Forces officer power-dived the Lockheed *P-38* faster than the speed of sound (780 m.p.h.), he proved that the plane was appropriately named *"Lightning"*.

Now Lockheed engineers have given "finger-tip control" to its fantastic speed by installing aileron boosters actuated by the revolutionary Hycon "Stratopower" hydraulic pump. The application of these boosters, made practical for the first time, turns the *P-38* into a *dog-fighter which out-maneuvers many single-engined ships!* And the faster response of *all* control surfaces makes it a deadly fighter—even in the thin air eight miles up.

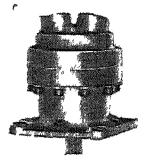
To help bring victory in 1944, we are increasing our output to the limit, and every Hycon "Stratopower" pump is reserved for our fighting planes.

LET'S ALL BACK THE ATTACK — BUY MORE WAR BONDS

At the war's end—for Tomorrow

Because of its compactness and phenomenally high pressure, furnishing *variable volume up to 3000 pounds per square inch*, the Hycon "Stratopower" pump will do a great many hydraulic jobs *better*.

Today there are available other Hycon pumps and valves in the 3000 pound range for commercial applications to control or actuate machine tools, giant presses, dump truck lifts, materials-handling mechanisms and remote control circuits. They will operate brakes, clutches and steering devices of heavy vehicles; test high-pressure apparatus, and solve a wide variety of other hydraulic problems. Write for full information.



HYCON ★ ★ ★

REGISTERED TRADE MARK

Stratopower Pump

Manufactured only by The New York Air Brake Company

THE NEW YORK AIR BRAKE COMPANY

Hydraulic Division

420 LEXINGTON AVENUE, NEW YORK 17, N. Y.

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of May, 1894)

SMOKE ELIMINATION — "In a recent experiment at Glasgow, Scotland . . . from 94 to 97 percent of the soot was removed from smoke and fully a half of the sulphuric acid. . . A Babcock and Wilcox boiler was used, driving a 220 horse power engine, and consuming 3 tons of coal and a ½ ton of scraps and chips. Before entering the usual chimney the gases ascend a short brick flue, and then descend a flue of steel plates dipped at a high temperature in a tar composition, entering the ordinary stack at the bottom. At the bottom of the ascending flue is a jet of steam at boiler temperature, while at the top of the descending flue is a fine spray of water. The carbon is thus separated, and, with the water, drops into a sump at the foot of the descending flue, being thence carried off in pipes."

LUBRICATION — "In a paper on lubrication, read before the Birmingham Association of Engineers, Mr. Railings the author mentioned the following as the requirements of a good lubricant: (a) It should be thick enough to keep a constant film between the two surfaces to which it acts as a separator; (b) it should be as thin as possible consistent with the first requirements; (c) it should be a good conductor of heat; (d) it should contain nothing that will act chemically upon the bearing it lubricates; (e) it should be difficult of evaporation and decomposition."

BICYCLES — "For many years man has attempted the construction of a successful road machine to be propelled by the rider. The first signs of real success came in the application of crank propulsion to the old velocipede. The next development was the introduction of elastic tires of India rubber. Then came the last and greatest improvement, the pneumatic tire. Meanwhile the proportions and details of the machine were constantly changing, until the wheel of to-day was evolved, with its ball bearings wherever possible, and with air-inflated tires."

AMMONIA — "Machinery is now being set up in Newark, New Jersey, for manufacturing ammonia from atmospheric nitrogen. Every farmer knows that nitrogen is one of the essential elements of plant food and that it is far the most expensive of the elements that are required in fertilizing mixtures. . . If ammonia can be cheaply manufactured from atmospheric nitrogen, the discovery means that a great step has been taken toward securing a material increase in the productiveness of the soil."

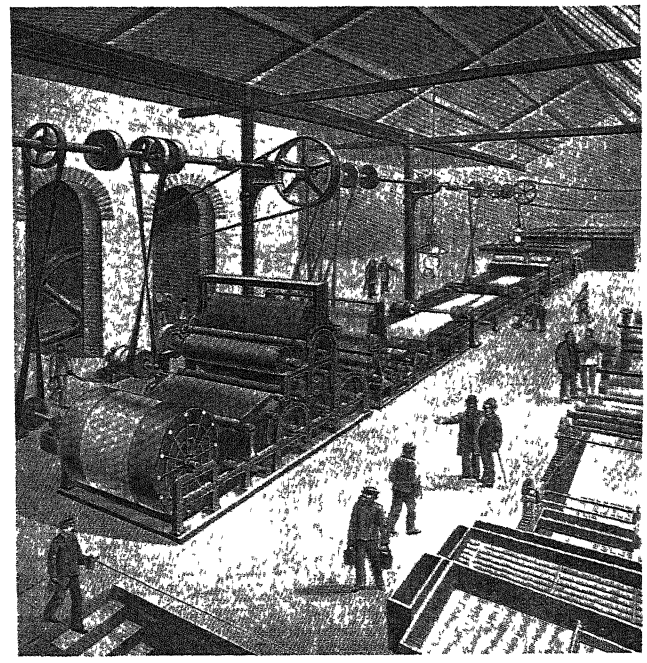
BATTERY CHARGING — "The employment of windmills for the charging of electric storage batteries . . . is now being done in England by the Rollason Wind Motor Company The motor consists of a set of five curved vanes fixed to a vertical shaft. These vanes measure 7 feet by 20 feet, the longer length being placed vertically. . . The motor drives a five horse power dynamo, to which it is connected by belt gearing. The dynamo is used to charge accumulators, and the latter supply a current which may be used for lighting or power purposes . . A magnetic cut-out is supplied, which breaks the circuit when the speed of the motor, and consequently the voltage of the dynamo, falls too low."

SCALES — "It is a trite saying that all modern science is built upon the balance. . . All the modern developments are due to the exact determination of weights and measures. Of late years the same fact has begun to hold in the case of the mechanical arts. The charges of flux and ore for the blast furnace and of steel for the crucible are now accurately weighed and precise results in metallurgy are obtained by the aid of scales. The same is true for many other branches of the arts."

RUBBER — "The authorities of Madagascar have just granted to the Hon. John L. Waller, ex-U S. consul for Madagascar, a concession, measuring in area 15 miles square, in the district of Fort Dauphin, on the southeast coast, and which is conceded to be one of the richest rubber districts on the island. . . Mr. Waller will stop the destruction of the rubber trees and vines by the natives, as far as his own concession is concerned, and will preserve them by having the milk extracted in a scientific manner."

ABYSSINIA — "As the European nations divide Africa among them, Italy is taking her share and has established a protectorate over Abyssinia. The eastern portion of this country, bordering on the Red Sea, is called Eritrea. This is ruled by a civil and military governor and three councilors appointed by King Humbert, and here an Italian colony has been started in the hope of bettering the conditions of the country and of lessening the tide of emigration to America."

CIGARETTE PAPER — "Good cigarette paper should be very thin, very uniform as to pulp, and very strong and resistant . . . Superior cigarette paper is manufactured exclusively from linen rags. . . Ordinary cigarette paper is manufactured from substitutes. Its pulp often contains a certain amount of wood pulp. . . In its broad lines, the manufacture of cigarette paper does not differ from that of ordinary fine paper A single point is special, and that is the finishing, which has to take a long time and be well done The pulp must be finished slowly, progressively, and with as short fibers as possible The duration of the process . . . varies between 15 and 30 hours. . . It requires a special manipulation and perfect machines to obtain a sheet of paper presenting great strength with a pulp composed of so short and so divided fibers By way of example, we give a figure of a continuous machine for cigarette paper constructed by Mr. Burot, of Angouleme."



ELECTRIC LIGHTING — "An article by Mr. J. H Talbot, in the Engineering Magazine, contains valuable information for city taxpayers or investors interested in the establishment of small electric light stations. If the facts in this article had been given to the public several years ago, without doubt a large waste of capital would have been prevented, and a great many enterprises of this kind now struggling under financial burdens might be in a prosperous and flourishing condition Mr. Talbot points out how very difficult it has been for persons desiring to establish an electric light station to obtain in advance accurate and definite information regarding its cost of construction and expense of operation, and it is his purpose to furnish such information."

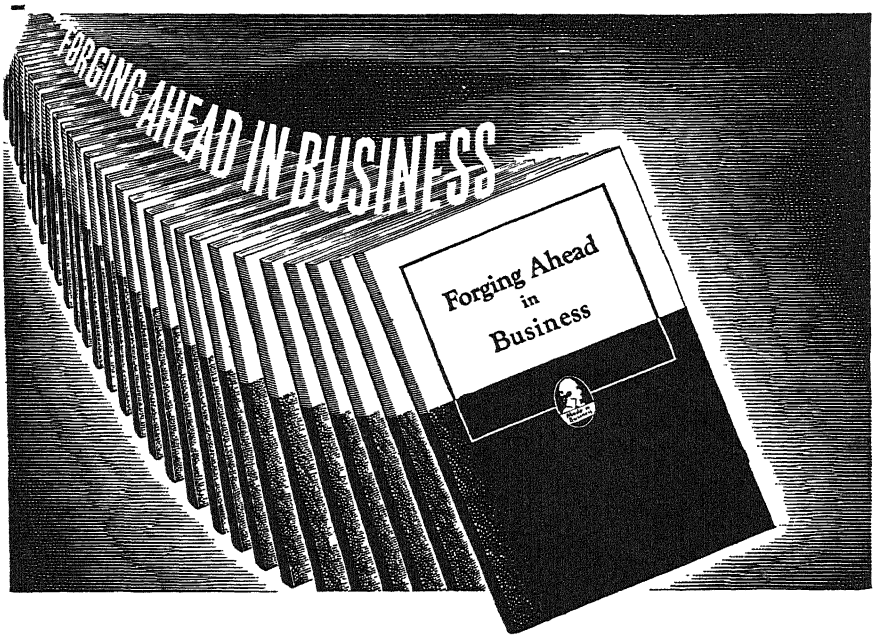
How long for a wartime Long Distance call?

A Long Distance call may be long in miles, but we hope you will try to keep it short in minutes. War needs the wires.

When you are calling on crowded circuits, the Long Distance operator may say—"Please limit your call to 5 minutes."

That's a good suggestion. It helps more calls get through during rush periods.

BELL TELEPHONE SYSTEM



All Serious-Minded Production Men

SHOULD HAVE THIS FREE BOOKLET!

FORGING AHEAD IN BUSINESS contains a message of particular importance to production men. This is your opportunity to obtain a copy of this famous book, which has been described as a "turning point in the lives of literally thousands of men"!

Although "Forging Ahead in Business" has been distributed to more than 3,000,000 men, today's timely edition was written in the light of recent world-wide developments. Its 64 pages represent more than three decades of successful experience in training men for leadership in business and industry.

It demonstrates the method which the Alexander Hamilton Institute uses to give you immediate help in your present position, while preparing you for post-war opportunities. Subjects directly related to the work you are doing now, PLUS other subjects of fundamental value to the business executive, are discussed in the book and placed in significant relation to one another. Thus, a helpful, over-all picture is provided.

Said one man who had sent for "Forging Ahead in Business":

"In thirty minutes this little book gave me a clearer picture of my business future than I've ever had before."

. . . and that represents the opinion of the Institute's 400,000 subscribers, *including 134,000 production men!*

The booklet further explains how it is possible to offer this essential training in a minimum of time; how the Institute program fits in with the most crowded of war-time schedules.

Among the prominent industrialists who assisted in the preparation of the Course, which is described in "FORGING AHEAD IN BUSINESS" are: Alfred P. Sloan, Jr., Chairman of the Board, General Motors Corp.; Thomas J. Watson, President, International Business Machines Corp., and Frederick W. Pickard, Vice President and Director, E. I. du Pont de Nemours & Co.

Send for "FORGING AHEAD IN BUSINESS" TODAY!

Frankly, this booklet has no appeal for the immature mind. It does not interest the man who, for one reason or another, is wholly satisfied to plug along in a mediocre job. But, for the alert, future-minded individual—the man with ambition and "drive"—"Forging Ahead in Business" has a message of distinct importance. If you feel that it is intended for you, don't hesitate to send for a copy today. Simply fill in and mail the coupon below.

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Please mail me, without cost, a copy of the 64-page book—"FORGING AHEAD IN BUSINESS."

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Firm Name.....

Business Address.....

Position.....

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"Quotes . . ."

"I BELIEVE the industry should be permitted to start plans and preparations now to build a limited number of new automobiles on the day the war in Europe ends, rather than delay this preparation for conversion until Japan is defeated." Ward M. Canaday, President, Willys-Overland Motors, Inc

" " "

"VAST INCREASES in the technique of mass production can be expected to lower production costs. New materials will be worked into consumer goods and better qualities developed. In the long run prices can be expected to come down and qualities can be expected to rise" *David R Craig, President, American Retail Federation.*

" " "

"THE UNITED STATES will be finished as a progressive dominant nation, if we regiment and unduly restrict free enterprise and free effort and if we block the path of 'the boy from across the tracks' to attain through his own efforts the highest position in the land." Harold V. Coes, President, American Society of Mechanical Engineers

" " "

"LOWER COSTS of operation due to greater production indicate but one probable direction in which the price of aluminum can go. The price has dropped since we entered the war from 20 cents to 15 cents a pound" *E. B Wilbur, New York Manager, Aluminum Company of America.*

" " "

"ARMY EXPERTS now estimate that, after the end of the European War, we may be forced to cut back our munitions production by approximately 80 percent and still have enough to fight a full-scale war against Japan. . This picture may prove, to be somewhat exaggerated but it serves to emphasize the fact that the major shock to our economy will come immediately after the end of the fighting in Europe, and not at some later date after Japan has been crushed" John F. Fennelly, Executive Director, Committee for Economic Development

" " "

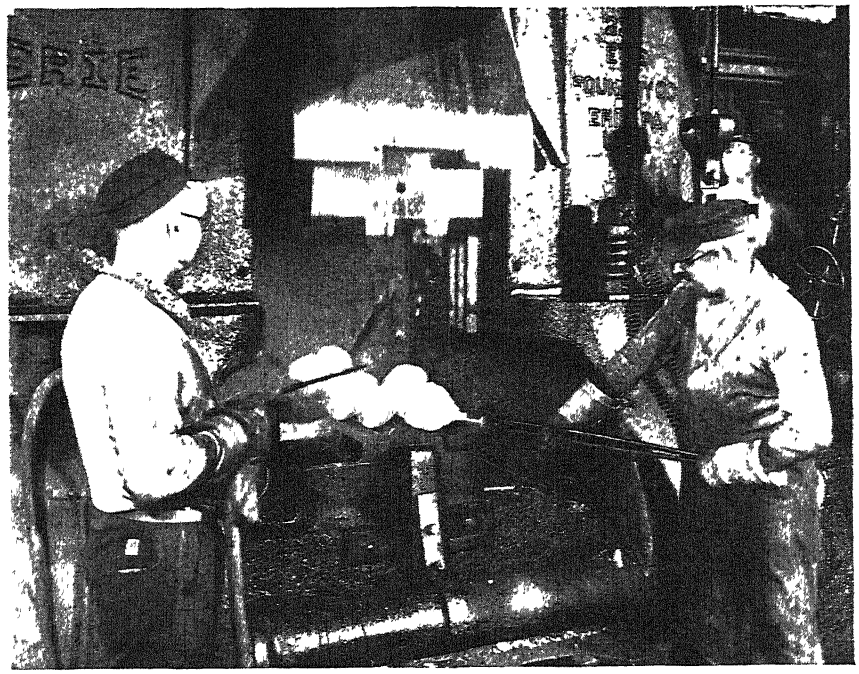
"THE FUTURE of America lies in the initiative and resourcefulness of its individual enterprises. If they manage well, the future is secure." *John R. Bangs, General Manager, Personnel and Industrial Relations, Budd Manufacturing Company.*

" " "

"WHILE WE HAVE nothing to show at this time, we are building up a great deal of experience not only in FM but in ultra-high frequencies and microwaves; experience in components, vacuum tubes, transmission lines, antennae, and all the new things that are necessary in this field." F. R. Lack, Vice President, Western Electric Company.

METALS IN INDUSTRY

Conducted by FRED P. PETERS



Courtesy International Harvester Company

An engine crankshaft as it appears after drop forging in a 12,000 pound hammer. The flash is trimmed from the forging in an adjacent press

Mass Production Metal-Forms

In Materials Engineering, the Choice of Metal-Form or Fabricating Method is Often as Important as Selecting the Metal to be Used. Process-Competition in the Small-parts Field is Especially Intense and Will Become More So in the Not Far Distant Future

THE COMPETITION among materials will shortly dominate the industrial scene. Post-war product planners appear to be increasingly preoccupied with the relative merits of aluminum, copper alloys, alloy steel, plywood, plastics, and so on, for their automobiles, helicopters, refrigerators and houses, and our press is full of speculation on the outcome.

One phase of this materials-competition, however, that easily escapes general attention is the rivalry among the "metal-forms" or fabricating processes. For not only do *metals* compete for the designer's attention, but the *methods* that can be used to manufacture specific parts and products are also a matter for choice, and in many cases become the primary factor in deciding which metal or alloy will be used for a particular job.

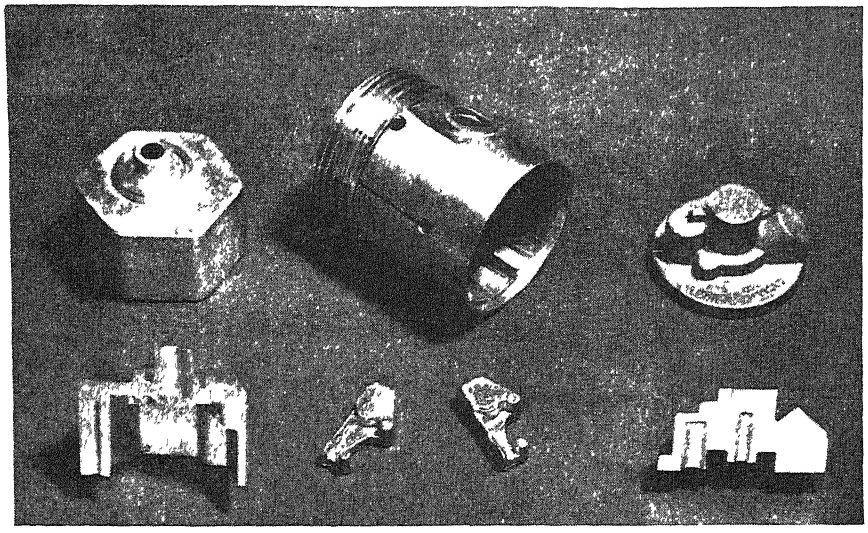
Thus, in developing his design, the engineer must give consideration to the factors of functional utility, mechanical quality, appearance, and production cost. When the product or part is to be manufactured on a mass-production scale the factor of production cost may easily predominate over the others. In such cases the first and most important choice may be how the part is to be made—shall it be a die casting, a screw-machine part, a stamping, or what?

Since the metals vary in their amenability to the various fabricating processes, the selection of the method frequently determines or at least narrows the choice of metal to be used. Some metals even find their market position directly dependent on the technical development and extent of application of a particular fabricating process, an outstanding example of this being the considerable dependence of the zinc industry on the popularity of die castings and the die-casting process.

Process-specification has become in this war a branch of materials-engineering virtually as important as selecting the materials themselves. We are at last learning that each high-production process has certain "design characteristics" which are as distinctive of it as are the typical properties of individual metals that might be considered for use.

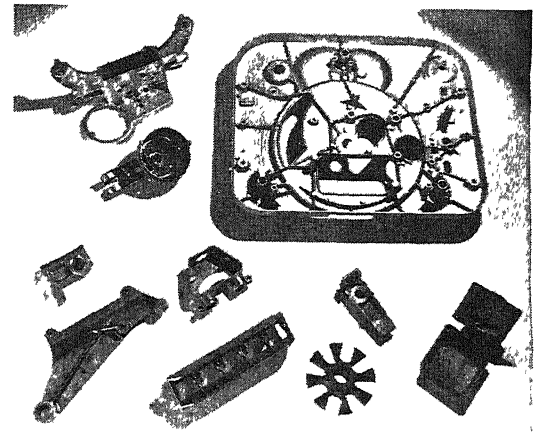
Small metal parts for industrial and consumer products may be made by any one of ten or so methods. The metal-forms most frequently met in the small part field are sand castings, permanent mold castings, die castings, precision investment castings, stampings, drop forgings, screw-machine parts, extrusions, cold-headed products, and powder metallurgy pressings.

SAND CASTING—Sand casting, the traditional and still the most common method of producing castings, consists in (a) making a sectioned wooden or metal model (called a pattern) of the part to be cast, then (b) packing molding sand around the pattern in a "flask," removing the pattern and drying the mold by baking it, and (c) pouring suitably prepared molten metal into the mold cavity. When it has solidified, the casting is "shaken out" of its



Above: Permanent mold castings in aluminum alloys, as produced by the Permold Company. The sectioned castings show fine-grain density

Right: Die castings typical of those produced in various alloys. The three at the top are zinc alloy; the four in the lower left corner are aluminum alloy. The box and cover at the lower right are brass and the remaining two were cast from magnesium



Courtesy New Jersey Zinc Company

mold, the latter being destroyed and the sand returned for reuse or discarded

The casting usually must be machined to finished dimensions since its surface is rough and the sand mold lacking in precision. Sand casting's tolerances are wide—1/16 to 1/32 inch per inch being normal for the process.

For small parts, sand casting can be very rapid, since several molds may be poured simultaneously. Tool costs are low, for expensive steel dies or molds are not involved, but labor costs are likely to be high. Its design flexibility—*i.e.*, the ability to make complicated, cored, and undercut parts in one piece—is very high, since the mold is expendable and cannot interfere with the removal of even the most complicated shape after the latter has been cast.

Sand castings may be very large—several feet in height or width, but they cannot be as small nor as thin-sectioned as parts made by other methods. Gray cast iron, malleable cast iron, steel, brass and bronze, aluminum, and magnesium are the materials in which most sand castings are produced.

PERMANENT MOLD CASTING—Permanent mold casting (called "gravity die casting" in England) involves manual pouring of the molten metal under a gravity head into metal molds. The molds are made in sections, and assembled, and remain clamped together during pouring and solidification of the casting.

Permanent mold castings are dense and fine-grained, and can be made to closer tolerances than sand castings (although tolerances must be wider than for die castings and the other forms.) Surfaces are of course better than those of sand castings, but tool charges are higher. Permanent mold castings are made in zinc, aluminum and magnesium alloys, bronzes, and cast iron.

DIE CASTING—Die casting is done in fast-working machines that transfer or inject under pressure the right amount of molten metal into a metallic water-cooled die set that remains closed until the casting is solid. Some machines are able to produce 300 to 800 "shots" per hour, which may mean 6000 parts per hour through the use of multi-impression dies that are used simultaneously.

Die casting's strongest points are its excellent precision (tolerances as close as ±0.001 inch can be held) and the high production rates often achieved. Because die castings seldom need to be machined to meet tolerances and because of the high productivity of the process they are among the most economical of the mass-production metal-forms.

On the other hand, die casting has its limitations. Die costs are a sizeable factor, although not so great as for some of the other methods. Casting shapes are limited in complexity, for undercuts and cross-holes cannot be included unless the dies embody expensive slides, collapsible cores, and so on. The cost of these extra die features can often be justified; sometimes the use of an exterior undercut saves metal by providing uniform section thickness, or, again, a part with necessary undercuts may still be less expensive to make by die casting than by other methods.

Because of the effect on die costs, die castings are chiefly made in low-melting-temperature metals like zinc alloys, aluminum and magnesium alloys and in general their mechanical properties are, therefore, lower than metal-forms like machined steel, steel forgings, high-strength iron sand castings, and so on. But it should be remembered that die castings as a class are not at all the unsound, porous, and weak materials of many years ago, and that where maximum strength is not required they are serving nicely today for many applications even of a structural or engineering nature.

Most die castings are made in zinc alloys, although the proportion made in aluminum alloys has sharply increased, and the position of zinc as the No. 1 die casting metal may some day be assumed by aluminum. Magnesium alloys, too, are increasingly used for die castings. Where high mechanical properties in a die casting are sought, brass may be employed, although die costs are thereby raised considerably.

PRECISION INVESTMENT CASTINGS—The increase in use of precision castings made by the "lost wax" or similar processes (described in Scientific American, December, 1943) has been one of the important wartime production developments in the metals field

The method employs a plaster or refractory-material mold for the final casting of the metal, the mold is discarded after each cast, and hence the casting may be quite complex.

The method in fact combines the permissible design-intricacy of sand casting with precision close to that of die casting. (Tolerances may be from ±0.005 inch to 0.003 inch.) Considerable skilled labor is involved and there is some material waste in the form of sprues. Production rates may be high, but for very small parts cannot compare with die casting or powder metallurgy.

Very high melting-point metals can be cast in complicated shapes to fairly close tolerances by this method. Brass, bronze, steel, stainless steel, and heat-resistant alloys (in addition to the precious metals) are regularly made into precision castings.

POWDER METALLURGY—Fabrication of small parts by powder metallurgy methods involves (a) pressing of metal powders in a mold or die to form a weak, "green" briquette of roughly final shape, (b) "sintering" the briquette and bringing it to service strength by heating it to some temperature below its melting point, and (c) re-sizing or coining the sintered part to final, exact dimensions.

Powder metallurgy is able to provide certain structures or metal-combinations that are not producible by methods involving melting. For such work—

for example, the manufacture of oil-less bearings, tungsten carbide tools, porous metal filters, and so on—it is competitively out of reach of the other processes But it is also being widely advocated and increasingly used as a method for making small parts on a mass-production scale to very close tolerances, in direct competition with machined parts.

Powder metallurgy machine parts can be made to tolerances closer than ±0 001 inch and at production speeds normally in the range of 200 to 1600 parts per hour. Metal powders, however, are among the most expensive of raw materials, tool and die costs for powder fabrication are relatively high; so far only the simplest shapes can be made by the process, and, finally, the mechanical properties of powder parts are never outstanding.

Actually powder metallurgy has suffered from over-glamorization. Its applications have been vastly extended during the war, with considerable saving to the nation in machine-time and critical materials, and this has given rise to a popular impression that the process is a fabrication-panacea that may even put the machine tool industry out of business. Intelligent opinion in the powder metallurgy field deplores this situation, for it is already leading to misapplications, disappointments, and the inevitable "black eye"

Powder metallurgy is a highly useful, economically attractive mass-production process, but it is employed within certain definable limits (no different, indeed, from any of the other fabricating processes in this respect.) Its future in the competitive phase is still uncertain and may depend on our ability to produce a good grade of iron powder at a much lower price than at present and under the kind of competition which powder metallurgy must face from the other processes.

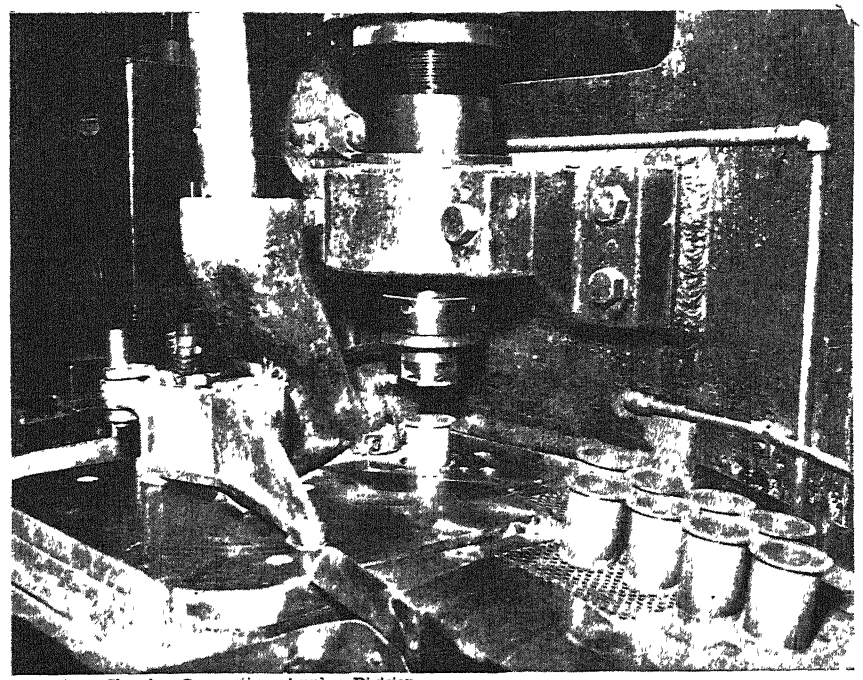
SCREW-MACHINE WORK—"Screw-machine products" are usually made on a hollow-spindle turret lathe adapted to automatic operation. These products are not necessarily screws or even threaded parts, but are considered to include all types of small machined parts produced rapidly and repetitively from bar stock or tubing and involving surfaces that are turned, formed, faced, drilled, bored, threaded, or cut-off.

Screw-machining's production rates are among the highest (up to 3600 pieces per hour) and its tolerances the closest obtainable in any of the competing metal-forms. The surface finish on a screw-machine product is smooth and lustrous. There is, however, considerable waste metal involved in the process and the design flexibility is not unlimited. The materials most used are free-machining steel, free-cutting brass, aluminum alloys, and magnesium alloys—all being wrought metals with good mechanical properties.

COLD HEADING—Cold-heading is a gathering-up or upsetting operation in which (usually) bar stock is gripped between dies in a header and pressure is applied upon the stock ends to produce a thickened section or flange wherever desired. Because it is done with great rapidity and without metal-waste (as in screw machining) or heating (as in forging), cold heading is a widely used process, being virtually standard for making bolts, screws and rivets in all but the smallest sizes.

Cold heading is one of the least expensive fabricating methods where large production is required and the design is suitable Tolerances may be held to ±0.002 inch per inch and finishes are excellent. Tool costs are high and limit the economical use of the process to jobs involving large numbers of parts of a given design.

The materials commonly cold-headed include plain and alloy steels, stainless steel, brass, bronze, and aluminum alloy, in the form of cold-drawn wire.



Courtesy Chrysler Corporation, Amplex Division

A briquetting press which forms parts in powder metallurgy

DIE FORGING—Die forging is a process in which heated metal is pressed, hammered or upset to its roughly finished shape between dies whose cavity is an approximation of the shape of the part desired. A press forging is made in a hydraulic or mechanical press, a drop forging in a drop hammer, and an upset forging in an upsetter.

Die forging's best known advantage is the strength or toughness of the metal part. Tolerances are fair, ±0.010 to 0.015 inch being normal, with ±0.004 inch possible at extra cost. Design flexibility is quite limited in die forging. Metal waste in forging is more than in die casting or powder metallurgy, but considerably less than in sand casting. Because of the pressures and temperatures involved, die costs are too high to allow the process to be used for anything but high production work.

For such work, however, where precision is adequate and especially where mechanical quality must be highest, die forgings (even though often more expensive than other forms) are highly satisfactory. Virtually all industrial metals and alloys are made into die forgings, according to requirements

STAMPING—Stamping may be defined as the blanking, pressing or forming of metal parts out of sheet or strip, using presses (or in some cases, drop hammers with soft dies and punches). The process involves (a) punching out a flat "blank" from the sheet metal, (b) forming this by bending or folding in a suitably shaped die, and (c) drawing the metal by stretching it over parts of the die or punch.

Stampings are typical mass-production parts whose manufacture involves high tool costs, low raw-material costs, medium labor charges and some waste Very thin parts (thinner than those possible by powder metallurgy or die casting) can be formed to tolerances down to ±0.001 inch; larger parts must usually have tolerances wider than ±0.003 inch. Production rates may be as high as 3000 per hour, and surface finishes are excellent.

Design-shapes of stampings are limited to those that can be formed out of sheet metal. The materials that can be used, however, are plentiful, numerous, and among the least expensive raw materials available. Steel, stainless steel, tin and terne plate, brass, bronze, nickel, Monel, and so on, are all widely used to make stampings.

The war has produced a sharp trend toward stampings because of the availability of presses and the fact that a cheap, non-critical metal like steel sheet can be used in replacing aluminum castings, brass forgings, and so on. (See Scientific American, November, 1943.) Much has been learned about designing for stampings and about their frequently surprising economic utility, and they should do well in the post-war era.

For the quantity type of production that the automobile industry, for example, is expected to require, stamping and die casting should continue to be highly attractive for small parts in the body and chassis. They provide the fastest production and within very close

(*Please turn to page* 235)

Wood In War Construction

Many of the New Uses for Wood which Have been Developed as a Result of War-Speeded Work Will be of Value in Peace-Times. Plywood, Laminated Timbers, New Connectors, and Design Improvements Point the Way. Large Industrial Buildings as Well as Small Homes All Benefit

By A. N. CARTER
Editorial Staff, *Engineering News-Record*

FEW MATERIALS have played a greater or more versatile role in America's war construction program than wood. Timber girders of unprecedented span have been built of plywood, huge timber beams have been formed of glued laminated boards, and, with the aid of ingenious metal ring connectors, timber has been used for giant blimp hangars.

Wood and wood products are being utilized for many types of construction. These include enormous quantities of lumber for military housing accommodating several million men, huge industrial buildings, airplane hangars, wharves, water tanks, warehouses, mass housing, bridges on highways and railroads, and for mold lofts and other shipyard facilities. Likewise, wood is a ready substitute for critical materials in fabricating drainage pipe and even for such small but important items as washers for bolted connections.

So great is the demand for wood that lumber production has soared to new records. Production in 1942 of 36.3 billion board feet was the highest since 1929, and that for last year was about 33.5 billion board feet. Among other things, these unusual demands for lumber and timber have resulted in development of more economical designs of end products, and the need to economize has caused widespread use of precutting and prefabrication techniques.

To appreciate the significance of the new techniques in timber construction, it is necessary that an understanding be reached regarding plywood, laminated construction, and ring connectors.

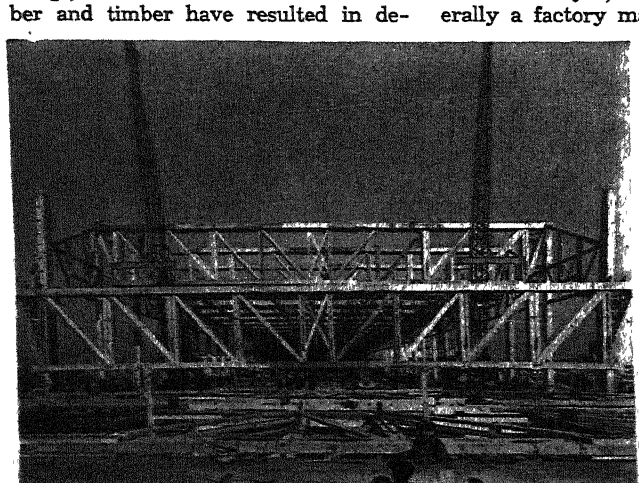
Plywood is not new, of course, but war construction needs have widened its versatility. This material consists of a combination of three or more sheets of wood veneer glued together, with the grain of alternate plies usually placed at right angles. Various glues are used, including phenolic resin, urea resin, casein, and those made from animal blood. After the glue has been applied the layers of wood are placed in a press to assure thorough bond between all layers. The presses may be of either the "hot press" or "cold press" type, the latter being used in the manufacture of water-resistant plywoods.

Laminated construction is a form of fabrication in which boards—generally of one-inch thickness—are glued together with the grain parallel. Large laminated members are often fabricated on the job, while plywood is generally a factory made product. Development of water-resistant glues accounts for much of the advancement in laminated construction.

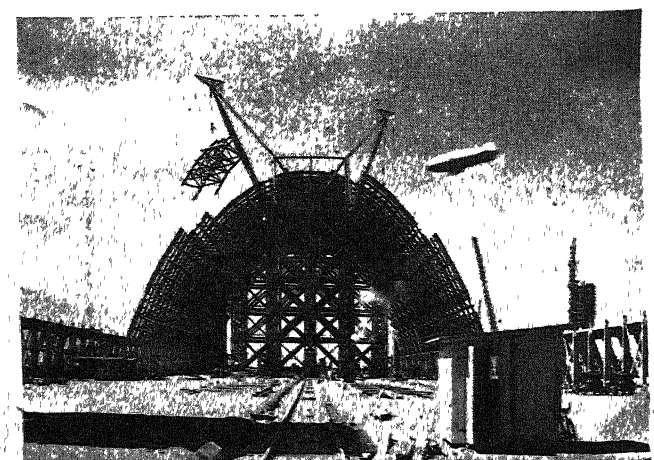
Ring connectors are metal devices for fastening and reinforcing the joining of wood members where they meet Two of the most common are the split-ring and the alligator types. The split-ring connector fits into grooves precut into the members joined, and the alligator type is pressed into the members to be joined. Other types fit into bored recesses. Whatever the type, they are all used for reinforcing the joint by providing greater shear resistance between members Connectors may be employed to strengthen joints where solid timbers, laminated members, or a combination of the two are joined.

One of the most interesting bridges to be constructed entirely of timber is the Fleming Park Bridge across a branch of the Ohio River downstream from Pittsburgh to connect Neville Island and the south shore. Swift currents and deep water are encountered at the site, and neighboring bridges constructed in the past were built with reinforced concrete foundations and steel superstructures to meet the severe conditions encountered. In contrast, because of the difficulty of obtaining steel, the new crossing was constructed almost entirely of timber, including the foundations

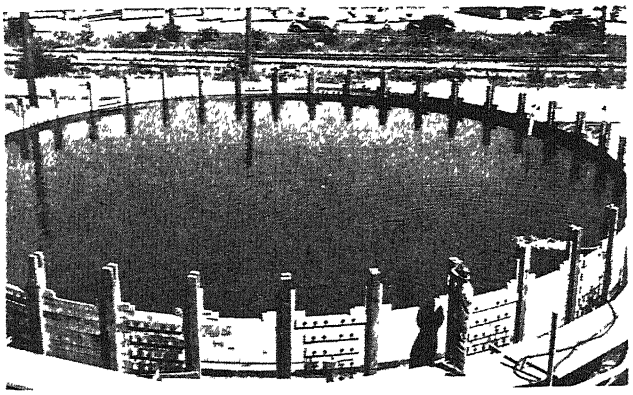
SIX TRUSS SPANS—The new bridge is not a small structure; it totals 1100 feet in length and consists of six 130-foot truss spans fabricated with ring connectors. The roadway, which was designed to carry street car and heavy truck traffic, also was built of timber



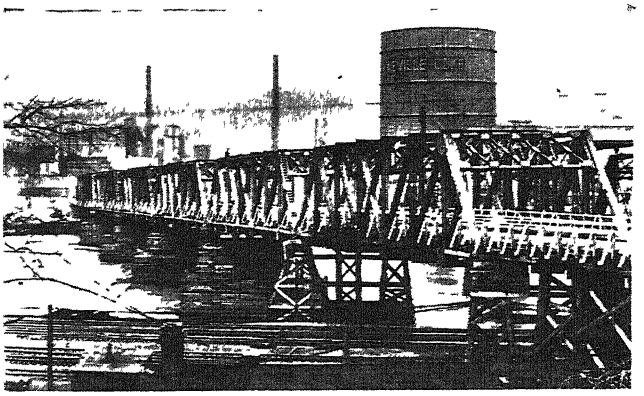
Largest industrial timber building—one of the Douglas cargo airplane assembly plants. A total of 27,000,000 board feet of lumber was used, saving some 30,000 tons of critical materials. The huge timber trusses have a span of 150 feet



This huge timber hangar for blimps required 3,000,000 board feet of lumber, or sufficient to construct 250 private homes. This structure, one of many built on seaboard sites, has a floor area greater than that of three football fields



By tightening the wedges between the vertical timbers, the horizontal staves of this new type of liquid storage tank are forced together to reduce leakage to a minimum



Designed to carry heavy truck and street-car traffic, this bridge across the Ohio River near Pittsburgh is of all-timber construction, even including the foundation

and includes floorbeams made up of solid timbers as large as 20 by 30 inches in cross-section. A total of 680,000 board feet of lumber was required for the superstructure alone.

An entirely different type of timber bridge construction is on an access railroad built by the Corps of Engineers in Florida. This structure was built of laminated timbers fabricated on the job with one-inch boards laid flat and glued together by a urea-formaldehyde adhesive. A few years ago this type of construction would have been impossible, and old time railroad men were skeptical that a bridge built in this manner could accommodate the heavy loads imposed by locomotives. The framing consists of three laminated stringers or longitudinal timbers of 9- by 20-inch cross-section under each rail. These stringers rest on timber pile bents on 15 foot centers and are capped with 12- by 14-inch laminated members. This structure is now carrying heavy railroad traffic

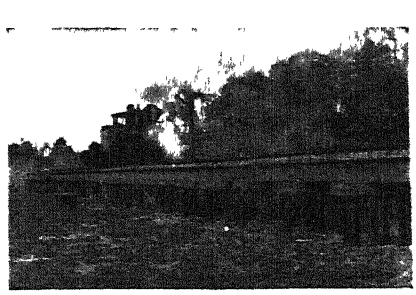
BLIMP HANGARS—Among the many unusual timber buildings which have recently been constructed, the most outstanding, perhaps, are the huge docks or hangars to house the Navy blimps used in patrolling our coastlines. A typical dock measures 1000 feet long, 297 feet wide, and 171 feet internal height to the crown of the roof, which means that a single hangar is large enough to accommodate three football fields, with room to spare.

The framing of these giant structures consists of timber arch trusses on 20-foot centers. The trusses are made up of solid members with all the joints strengthened by ring connectors. The secondary framing and roof also are of wood, a typical blimp hangar requiring a total of about three million board feet of lumber. Putting it another way, one of these giant docks calls for the use of as much timber as would be used in building 250 average-sized houses. All the timber used is treated to make it fire resistant

Other aircraft hangars have been built of laminated timber construction, some of record span. For example, at the Vandalia, Ohio, modification center of the United States Army, eight hangars were built with the principal roof framing consisting of laminated arch ribs on 10-foot centers. Two of the hangars are of such width as to require ribs of 177-foot span between abutments. Each of these ribs measures 7½ inches wide by 39 inches in depth and is fabricated of nominal one-inch boards of random lengths. The other six hangars required ribs of 157-foot span, these members being reduced in cross-section accordingly. The arches, fabricated in Chicago in three sections, were shipped to the site. When erected, they were braced with timber struts and steel diagonals and covered with a timber planking. This type of construction saved large quantities of steel, at that time badly needed for other purposes. Hangars of this design may be expected to give many years of service after the war ends.

Industrial buildings of tremendous size also have been built of wood. The largest in this country and perhaps in the world is the Douglas cargo airplane assembly plant completed last year at Chicago. This project required 27 million board feet of lumber, sufficient to construct a city of over 2000 homes. Use of timber resulted in a saving of 30,000 tons of critical materials.

Three types of timber roof framing —trusses, laminated beams, and plywood girders—have been common for industrial buildings. The trusses have been of several types, including those of the bow-string shape (that is, with curved top chord and horizontal bottom chord), those with parallel top chord and bottom chord, and still others of a shape designed to provide a saw-tooth roof. Ring connectors have been used in fabricating all types, some with spans of 200 feet. With the bow-string type the top chord often is of laminated construction, but most of the truss members are solid timbers Columns supporting the roof trusses likewise are made of timber, as are the smaller roof members.



The ties of this bridge, designed to carry heavy railway traffic, are solid timbers; the large members are laminated of one-inch lumber

Large laminated beams also have been erected as part of the roof framing of many industrial buildings At a midwest ordnance factory, laminated beams 60 feet long, 38 inches deep, and 7½ inches wide were erected. These members, which are supported on reinforced-concrete columns, were fabricated of southern yellow pine and west coast Douglas fir lumber one inch thick, eight inches wide, and of random length. In fabricating these beams, no bolts or nails were required, the boards being held together by casein glue. Glued scarfed joints were formed where the boards had to be spliced, the splices being staggered

ADVANTAGES OF LAMINATION—Use of laminated beams not only permits a large saving of steel, but also offers the advantage that they can be fabricated of lumber of a size most commonly available. Furthermore, they are economical to fabricate and the work can be done quickly. An added advantage is the fact that the height of the finished building is less than if trusses are used for the roof framing. Moreover, the beams permit rapid erection, an important factor in war buildings.

Plywood girders of large dimensions were introduced in constructing office and industrial buildings to save steel This type of girder, which is one of the most unusual developments of the war, is easy to erect, light in weight and may be expected to have a long life The girder also is remarkable for its length—60 feet—and the thickness (1½ inches) of its plywood web, or central portion.

The flanges or top and bottom stiffening members of the girder were each made of light 2- by 8-inch timbers These timbers were joined to the web by wooden dowels, which eliminated large quantities of iron for bolts. When erected to become part of the roof, the girder was supported on timber columns. On most of those projects where girders of this type were used requirements for critical materials were reduced still more by using smaller girders of the same general type for the secondary roof members

Formerly the Achilles' heel of timber construction, joints are now strengthened with ring connectors. Those shown are of the split type fitting grooves cut into the timber

Greatest advance in mass housing for war workers, for which vast quantities of lumber have been required, has been extensive precutting and prefabrication at a central yard to permit assembly-line production of walls, floor, and roof in panels of a size conveniently handled by a few men. Several advantages are evident: Greater economy of materials, increased speed in erection, reduced cost per dwelling unit, and addition of demountable features that would permit the buildings to be dismantled later and moved to a new site.

Success of the prefabrication scheme in war work is proved by the many speed records established. One contractor built 5000 dwelling units in five months in an eastern city. Records on other projects were equally spectacular. Furthermore, experience of the National Housing Administration in dismantling a large number of the dwellings for erection elsewhere has shown this feature to be practical. In the dismantling work little breakage occurred and only small damage resulted in trucking the sections long distances to a new site.

PLYWOOD IN HOMES—Another development in housing has been the extensive use of plywood. On many projects the interior partitions and ceilings are of this material. Also, since it can be made water-resistant, large quantities are being used for the exterior walls. This latter use has resulted in the development at one large project of "single-wall" construction. By this method the greater portion of the walls was made of prefabricated panels consisting of one-inch rigid insulation board covered on both sides with plywood. Use of this type of material simplified and speeded erection. In addition, the cost was found to be low. Moreover, the construction offers certain advantages from the standpoint of demountability.

Space will not permit detailed description of all the other timber structures that have been built, but a few should be mentioned. At numerous military installations and industrial plants, elevated water tanks have been built of timber staves supported on a tower of heavy timbers. In the past a steel tank resting on a steel tower was standard practice. With most timber tanks the staves are placed vertically. However, another type of timber tank has made its appearance on the Pacific Coast. This design was used where storage at ground level was wanted. The timbers are placed horizontally and a clever arrangement was worked out whereby timber wedges could be used to eliminate leakage, steel hoops not being required. A tank of this design has high salvage value. Furthermore, such a structure may be dismantled quickly, moved elsewhere with little breakage, and reassembled in a short time. In addition, the original investment per gallon of storage is low and the tank can be used to store chemicals that would destroy other materials.

Other items of timber, which have made their appearance on war construction and can only be mentioned, are manhole covers, water and sewer pipe, derricks at shipyards, and wooden tires for construction equipment.

More has been learned about timber by American engineers in the last few years than in any equal period in history, and one of the greatest assets of the war may prove to be the increased knowledge of wood and wood products. Many of the present uses for wood are attributed to the shortages of other materials. Nevertheless, many of the new uses will continue and much that has been learned will prove of value in peacetime.

"SAND JACKS"

Speed Ship Launching, Save Working Time

Use of "sand jacks" eliminates the need for driving-up wedges formerly used to transfer the load of newly constructed ships to cradles just prior to launching. The new method, devised by the Houston (Texas) Shipbuilding Corporation, has saved 3000 board feet of lumber and 400 man-hours of time at each launching since its introduction last October.

Steel sand boxes, about 24 by 12 inches by 6 inches deep, made in top and bottom halves, are set on the principal load points at the keel of a ship. Similar boxes of 8- and 9-inch diameter pipe are used under the bilge cribbing. Each steel box has a filling hole in the top and a drain hole equipped with a pipe plug in the bottom section.

Before the keel is laid, the bottom sections of the boxes are filled with sand that has been thoroughly dried by heating. Next the top sections are installed and these sections filled to the top hole. Finally, the pipe plug is inserted.

The day before launching, the grease bars between the ground ways and the slides are removed, and the packing of the cradle is wedged up snugly but not sufficiently to take the weight of the ship. On launching day the ship is lowered to the launching cradle simply by removing the drain plugs and permitting the sand to flow out. To launch the ship, the top blocking in the launching way is removed, the dog shores are released, and the sole plates forward are burned off, which releases the vessel.

PRESTRESSED CONCRETE

Now Available For Water Pipe

An advance in the art of making reinforced concrete pressure pipe is represented in the utilization of the principle of prestressing steel in tension and concrete in compression. Manufacturing methods recently devised by the Lock Joint Pipe Company resulted in a saving of 1000 tons of steel on an installation of 75,000 linear feet of 30-inch pipe.

The new prestressed concrete pipe follows the general Lock Joint design in that it has a continuous welded steel cylinder with steel joint rings forming bell and spigot ends. However, after the cylinder is centrifugally lined with concrete to a thickness of 1⅞ inches and the concrete has been properly cured, the lined cylinder is spirally wound with number 6 high tensile strength wire under tension, imparting an initial compression in the cylinder and concrete core. The steel structure of the pipe is protected by a coating of cement and sand mortar ¾ inch thick.

The design of the pipe is such that the concrete will always be in compression under operating conditions. Recent tests on two of these pipes showed that they were able to resist pressures varying from 1450 feet of head to 1665 feet.

CONCRETE BUILDINGS

Exhibit Unusual Construction Details

Reinforced concrete played an important role in the construction of certain industrial buildings last year. One of the notable projects was the plant built for the Dodge Division of the Chrysler Corporation in Chicago; the main building in this plant covers an area of 80 acres. More important than its size, however, was the use of multiple thin-slab concrete roof arches supported on concrete columns, in a design that required only 2.7 pounds of reinforcing steel per square foot of floor space.

Another significant concrete building was an auditorium at an air station in the southwest wherein 91-foot span ribs having only a 25-foot rise were used. Cast on the ground, the ribs were raised a half section at a time, the hinge splice at the crown consisting of a short section of 10-inch diameter steel pipe; bottom ends of the arches were rounded to fit into recesses in the footing.

Progress By Substitution

A Brighter World is Promised by the Surface-Coating Industry as the Result of Substitutes Developed to Replace War-Restricted Materials. New Drying Oils, Some Produced by Synthesis, are being Used in Paints With Excellent Results. The Industry Now Has a Wide Choice

DON'T LOOK down your nose at substitutes. You may regret it. Substitute—the word itself—seems always to carry with it a strong implication of inferiority, of paper collars and wooden nutmegs. That is unfortunate and often untrue, since industry progresses by processes of substitution. Indeed, the industry of paints, varnishes, and protective coatings has reached its present important position in our economy by a continuing progression of substitutions. And its future is now being built upon a number of additions to the series, each of which seems well on the way to becoming as firmly established as any of its ancient arts. From these new substitutions, our world, particularly our homes and our belongings, will be brighter, much brighter, as soon as wartime restrictions are lifted.

Shortages struck the protective-coating industry early, when this war was only a clash between Chinese and Japanese and long before it had taken on global dimensions. For China had supplied a large proportion of the industry's necessary drying oils, particularly tung and perilla, and the blockade of China's coast interposed itself effectively between producers and consumers. That was bad, and paint and varnish producers were severely handicapped by the shortage of two of their important oils. But the situation was saved by the ability and dexterity of the industry in substituting.

The amount of tung oil available to the industry now has dropped to somewhat less than 10 percent of the amount consumed in 1936, a shrinkage that might have caused a major catastrophe in a less versatile industry. As a matter of cold fact, the supply of tung oil available in 1943 represented something like half of the quantity of this oil used in, say, 1912. Tung oil had in little more than a score of years gone through the complete upswing of the cycle that was undone in a much briefer period by war in the Orient. Tung oil's sound position in 1936 had been attained from that of a substitute in America in a little over two decades. Now other substitutes taking its place temporarily seem destined to become permanent in the same way.

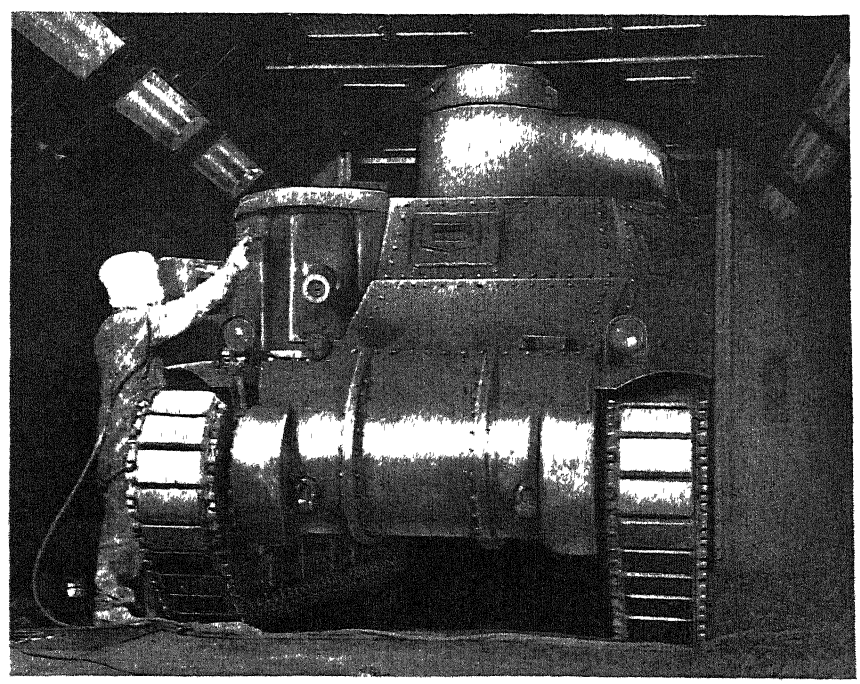
Efforts to grow tung oil in this country, extending back over a score of years, have provided groves of tung trees on our Gulf Coast that still can supply only a small part of our needs of this oil. Since the trees must be mature to yield oil-rich nuts, groves develop slowly over several years and the process cannot be hastened. Perilla oil, required in substantially smaller amounts than tung oil, comes from the seeds of an annual plant which, although not native to to North America, can be grown here, but is not.

To a limited extent, the several drying oils used in the manufacture of protective coatings can be interchanged, but the tendency throughout the industry has been to use mixtures of several to produce exactly the result desired, often unattainable otherwise. Therefore, the obvious necessity was and is to provide other oils from more plentiful sources to impart the desired qualities to mixtures, whatever may be the characteristics of the individual oil itself. Primary ingredients in customary mixtures have been linseed, tung, perilla, fish, and soybean oils. With two of the five missing, others had to be found to take their places. Current conditions are nearly ideal for developing any newcomers and for proving their worth.

Synthetic processes and a number of new separation methods now convert more plentiful oils into forms having some of the essential qualities of the missing orientals. New oils, too, are proving useful. As a result, it may even become a matter of indifference to us whether the tung and perilla oils are ever again available in their old abundance.

INITIAL STEPS—First among the steps taken to meet the impending shortage was, naturally, a search for other oils that might serve without modification. Oiticica oil, obtained from a nut native to Brazil, showed some promise and has been further developed. However, the limitations of a tree-borne nut, whose production could not be increased quickly, and the fact that its native soil lay outside our borders, interfered with universal usefulness. Furthermore, while oiticica oil is valuable, it is by no means as versatile as tung oil, and solves only a part of the problem Several other oils investigated also failed to meet more than a small fraction of the need.

At this juncture, synthesis—or better,



A tank gets a quick coat. Production of war-needed materials has placed great demands on the surface-finishes industry, already faced with shortages

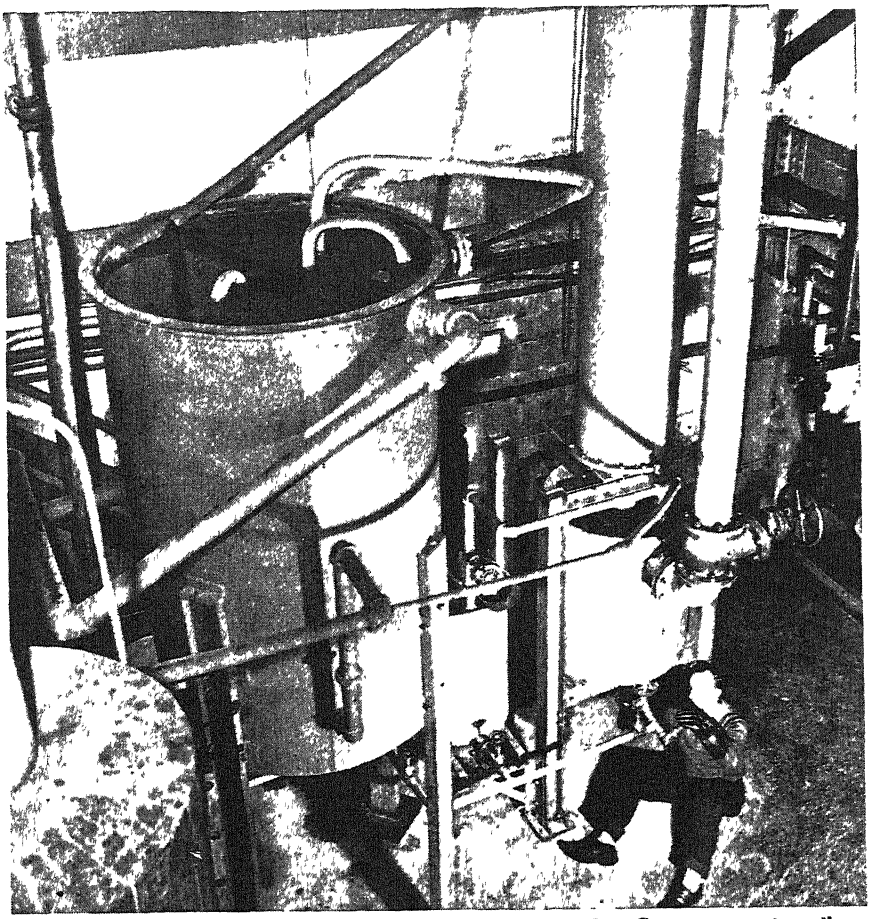
perhaps, semi-synthesis—entered the picture. Castor oil, some of whose properties are familiar to everyone, is chemically peculiar. Although in its natural state this oil possesses no drying qualities at all, its chemical constitution is such that the mere removal of water from its molecule gives it exceptionally high drying quality. The process is neither difficult nor particularly expensive, and the treated oil possesses important resemblance to tung oil. Here again the question of quantity was important, for the ordinary source of castor oil was a bean imported from Brazil and from India However, the castor plant grows readily in most of the United States and luxuriantly in the Gulf Coast area, producing beans in a single season. Thus in the period since 1936 a substantial production of dehydrated castor oil, made by several methods, has been attained to offset a considerable part of the growing shortage of tung oil.

Let it be clearly understood that dehydrated castor oil is not a complete substitute for tung oil. Neither is any other oil yet available. However, both its similarity to the older oil, as well as its peculiar individual properties, make dehydrated castor oil too useful ever to be completely discarded, even when tung is again plentiful.

A third important phase of current development is the separation of constituents possessing exceptional qualities from oils ordinarily considered non-drying and hence of little or no value in the protective coating industry. Thus soybean oil of limited drying qualities can be separated by the relatively new technique of molecular distillation under extremely high vacuum into fractions of differing properties. One of these fractions possesses substantially enhanced drying qualities and the remainder is quite as good as, if not actually better than, the original whole oil for making soap. Similar separations can produce especially useful fractions from linseed oil, from cottonseed oil, and from several others. The treatment increases the cost of the useful drying fraction somewhat above the original value of the oil, but since it provides products of special usefulness from plentiful domestic oils, the final cost is not excessive.

COMPARABLE RESULTS—Solvent extraction of raw oils can effect a similar separation. This method takes advantage of the difference in solubility of drying and non-drying constituents in certain solvents—dilute methanol, for instance. The separations effected by the two methods are not identical, but the results are comparable.

Finally, changes in the chemical constitutions of the fatty acids of oils have been effected by treatment with alkalies in a process somewhat similar to the soap-making operation but more severe and prolonged. In essence this process consists of converting the oil into a soap, heating the soap, and subsequently recovering the altered fatty acids from the soap. The change effected is a re-arrangement of the double bonds within the fatty acid molecules into positions more favorable from the point of view of drying power. The resultant fatty acids from the process are recombined with an alcohol to reform the oil. The alcohol may be glycerol, recovered from the soap-making operation and a normal constituent of all natural oils and fats; or it may be another alcohol, glycol, or pentaerythritol, which yields special types of oil differing essentially from the original. Pentaerythritol, produced from formaldehyde, forms oils having exceptional drying values and particularly useful in the alkyd resins used in making modern varnishes. Thus this technique introduces types of oil not duplicated in Nature.



In this equipment, in a plant of the Woburn Degreasing Company, castor oil is processed to obtain a drying oil that will replace tung oil in surface finishes

The combined effect of all these various measures of substitution has been to provide the protective-coating industry with a series of new oily materials used in formulating the great variety of paints, varnishes, and protective and decorative coatings required by modern industry. Yet these are only a part of the story. The natural resins, the copals, have long been employed in making varnishes for direct use or as the vehicles of pigmented enamels. These have also been subjects of a program of synthesis as supplies of the natural products have diminished. Most important of the diminishing natural resins are the so-called fossil gums which impart hardness and brilliance to varnishes. These are typified by amber and copal and probably are products of prehistoric forests. They are found buried in the ground and deposits of them are being worked out. Pine rosin is produced by growing trees and is so cheap, as well as so efficient in admixture with tung oil, as to belong in a class quite by itself.

REVOLUTION IN FINISHES—The advent soon after the close of World War I of nitro-cellulose lacquers of a character competitive with paints initiated an important revolution in industrial finishes. Because they dried with almost magical speed, these new products seriously threatened enamels and varnishes, which required as much as two weeks to produce a finish attainable with lacquers in a few hours First of the answers by the paint industry was a group of enamels based on varnishes compounded of phenol-formaldehyde resins and tung oil. These possessed practically the characteristics of familiar enamels except that they dried in a time comparable with that of the lacquers.

Subsequently quite a different type of resins, the alkyds, were developed for use in finishing automobiles. The alkyds are made from compounds of the type of glycerol and phthallic anhydride, for example, with the addition of drying oils as softening agents. They yield highly resistant films. By the application of heat, lately efficiently supplied by infra-red lamps, alkyd enamels can be dried in a matter of minutes or even seconds, in a chamber forming part of a production line. Thus delay for the finishing operation is completely avoided. Improved properties are imparted to the finishes by the addition of other resins to give the final film re-

sistance to wear, light, heat, moisture, and other destructive agencies far beyond that ever before attainable. Indeed, modern finishes of the modified alkyd type actually approach vitreous enamels in their resistance to destruction but are easier and simpler to apply. Enamels of this type can also be given the ability to dry in the air within a few hours and to yield films of extraordinary resistance to weathering, even proving satisfactory for marine use.

Because these synthetic finishes require minimal amounts of drying oils, they can be considered in a very real sense substitutes for them. In the present scarcity they extend enormously the usefulness of the meager amounts of tung oil available.

THINNER PROBLEMS—All of the protective coatings mentioned require a certain amount of added thinner to reduce them to working consistency. Turpentine, because of its high solvent power, has been the traditional thinner. Mineral spirit or naphtha produced from petroleum has also been widely used for this purpose. The nitrocellulose lacquers require solvents of a different type since nitrocellulose is insoluble in either of those previously used in oily vehicles. Various alcohols, esters, and ethers used are more expensive than either turpentine or mineral spirit. Indeed, the cost of the solvent required in preparing nitrocellulose lacquers constitutes a substantial part of the cost of the product, yet the solvent itself disappears as the coating dries. An advantage of alkyd finishes is their compatibility with low-cost solvents. The latest significant development in this field is the substitution of a water emulsion of the alkyd enamel—containing little or no solvent—for the customary solvent-thinned product. An emulsifying agent, such as casein, is necessary to form the combination but the result avoids costly solvents wasted in the drying of the final film. Furthermore, such emulsions are readily applied to porous surfaces to yield coating quite comparable with those formed by solvent-thinned enamels on nonporous surfaces. The presence of the residual emulsifying agent in the film reduces its resistance to moisture and rain, but for interior work these finishes are easily applied, quick drying, and highly satisfactory as to wear. Both their quick-drying character and their freedom from the "paint" odor of solvent are important considerations.

Brightness of finishes of the future will be much improved by using fluorescent pigments. These substances have the important property of glowing under ultra-violet rays, ordinarily invisible, and thus they add to the illumination of a room by employing this stray radiation. Investigations of pigments of this and other types sensitive to various invisible rays have been prompted by the need for special camouflage in war.

Thus shortages of specific drying oils, such as pertain at present, will soon be no longer significant in industrial and architectural finishes should they recur. Not, be it clearly noted, that we shall wish to forego the unusually valuable properties of tung and perilla oils when they become plentiful again. Rather we have added to the raw materials available to our protective-coating industry a number of new and valuable techniques and products that will supplement these oriental oils. Which we use will be a matter of choice and not of necessity.

And it all comes of substitutes Don't sneer at substitutes

* * *

SHARK VITAMINS

Content Varies Between Individual Fish

FISH-LIVER oils, important sources of vitamin A, have been sought in many sections of the oceans especially since the Norwegian fisheries have come under control of the Nazis. Latest important field to be investigated is the Florida coast, where sharks abound. A recent study of oils from the livers of different sharks in that region shows a variation of more than a thousand fold in their vitamin-A content. Apparently factors other than age, sex, and species affect this value and efforts are being made to determine the variables involved for the guidance of fishermen in sorting out their catch.

PLASTIC-GLASS

Combination is Light, Strong, Easily Molded

NOW BEING employed in aircraft construction and possessing hitherto unattainable strength in proportion to weight, a new material was recently described before the Industrial Minerals Division of the American Institute of Mining and Metallurgical Engineers by Games Slayter, vice president and director of research of Owens-Corning Fiberglas Corporation.

The new material is a plastic reinforced with glass fibers. Experimental samples, according to Mr. Slayter, have been produced with tensile strengths of over 80,000 pounds per square inch. While the impact strength of ordinary plastics is about two foot pounds on a standard test, samples of the glass and platic combination have shown impact resistance of over 20 foot pounds.

Another important feature of the new material, Mr. Slayter said, is that it can be molded into aircraft structural parts with low pressures and without the use of expensive molds. This reduces both the cost of fabrication and the number of man-hours required. The material can be machined and has the dimensional stability of metal.

Explaining the principle involved in the manufacture of glass and plastic combinations, Mr. Slayter said: "All materials contain imperfections. If the material is uniform in its structure, stresses accumulate around the imperfections Cracks propagate across the material and the material fails Nature guards against failure of her strong materials by fiberizing them. A tree consists of cellulose fibers bonded with lignin.

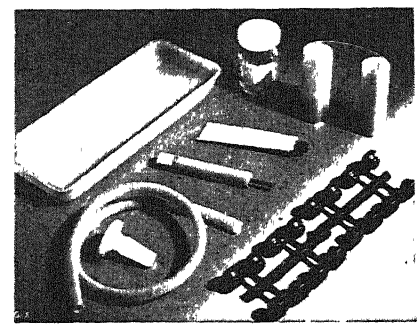
"When we draw glass into fine fibers and combine them with a plastic, we distribute the imperfections so that there is not one chance in a million that those in one fiber will match with those in another. The finer the fiber, the wider is the distribution of imperfections, and the smaller is the possibility that a stress accumulating at an imperfection will propagate through the mass"

POLYTHENE RESINS

Offer Desirable Intermediate Properties

A NEW family of resins, named Polythene, recently announced by E. I. du Pont de Nemours and Company, possesses properties intermediate between those of the soft synthetic rubbers and the usual harder resins. Polymerization of the hydrocarbon, ethylene, common among the gaseous products of cracking petroleum, is the source of the new resins now being produced in quantity, but under strict allocation.

Among the uses for which the Polythenes are adapted are collapsible tubes



Products of Polythene

for toothpaste and the like; waterproof coatings for textiles; electrical insulation for wires; and tubing and piping The outstanding characteristics of the new resins are: Toughness and flexibility over a wide temperature range; chemical inertness; unusual resistance to moisture and water vapor; and excellent electrical properties. Fabrication methods fit standard techniques and machines since the material can be extruded, injection molded, calendered on cloth, and machined by ordinary means

CORK SUBSTITUTE

Made from Plant-Waste Pith

A NEW compressible material adaptable for use in place of cork in bottle caps is reported by the Northern Regional Research Laboratory of the Department of Agriculture, Peoria, Illinois. The product is made from the pith of plant wastes and is yet in early stages of commercial development. It will be covered by a patent dedicated to the public and hence available to interested manufacturers in the United States without royalty

Prospecting for Petroleum

Man's Insatiable Curiosity About the Possible Wealth of Materials Hidden in the Ground has Led Him to Employ Many Weird Contrivances in His Search. As Science Advances, the Witch-Hazel Divining Rod Used for Locating Water Has Given Way to Electronic Techniques for Subsurface Probing

DURING the last two decades, methods of exploring for oil have undergone widespread advances due to the introduction of electronic equipment for geophysical prospecting.

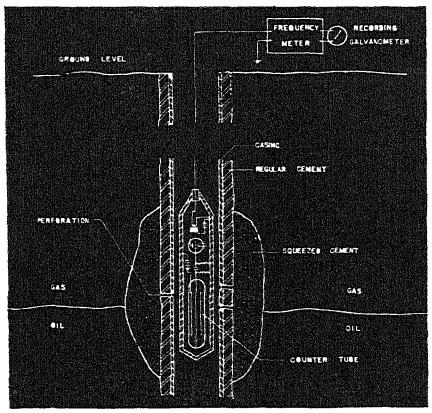
It was early discovered that oil pools occur in and around several different types of subsurface structures such, for example, as domes and faults. Once drilling operations have begun in an oil field, as much subsurface information as possible is gleaned from each well in order to map the subsurface structure. Such a map is useful in locating succeeding wells and in predicting the level at which oil may be found beneath the surface.

Within the last decade, "electrical logging" has been widely adopted. In general, the electric log shows two graphical traces as a function of depth: One a measure of the electrical resistivity of the formations, and the other a measure of the difference of potential between a point on the surface and a moving electrode in the well. These logs are made continuously as one or more electrode, suspended on a conducting cable, is moved in the well. Special trucks are equipped with power-driven cable drums and recording apparatus for making the logs.

Interpretation of electrical logs indicates that, with some exceptions, sands have a relatively high resistivity as compared to shales and also give rise to a relatively high potential peak. In many fields, new wells can be drilled between producing wells with fair assurance of success, using only electrical logs as guides. Thus, a large saving in time and money expended in examining core samples is effected. In "wildcat" or new-field wells, the electrical log sometimes shows up sands which are good bets as oil sands and which would otherwise be passed up.

THROUGH THE PIPE—Many established fields exist in which electrical logs cannot be used, due to the presence of steel casing. Some of these fields are known to have oil sands in the upper formations, sands which were not found when the wells were first drilled and cased. If these sands could be located *through* the pipe, production could be effected by perforating the casing with a special gun.

The fact that oil-bearing formations frequently contain radioactive materials has recently proved to be one solution to this problem. Gamma rays emanating from radioactive elements such as radium, the thorium series, and potassium can be detected through steel pipe and hence received early consideration in the search for a new well-logging technique. Lynn G. Howell, writing about the early work done in this field by the Humble Oil and Refining Company, describes their first gamma-ray detector as an ionization chamber filled with nitrogen at a pressure of about 500 pounds per square inch. Housed in a compartment adjacent to the ionization chamber was a detecting circuit and batteries. The ionization current was fed to the grid of an electrometer tube which was grounded periodically at three-second intervals by a clockwork mechanism. The grid voltage at the time of grounding was proportional to the ionization current, so that pulses proportional to the ionization current and, therefore proportional to radioactivity, were produced. These pulses were fed to the surface through the supporting multi-cable conductor.



Gamma-ray counter used to detect squeezed cement in an oil well

The pulses were amplified at the surface and read on a galvanometer. Measurements were made at various points in the well, a number of galvanometer deflections being read at each point. The producing sections of wells explored by both methods gave a promising correlation between the radioactivity curves and electrical logs made in the same wells.

Although the curves showed the possibility of using radioactive data in logging wells, the technique was not immediately applicable to making routine measurements. It is always desirable to make *continuous* logs, with as much speed as possible.

Geiger-Müller counter tubes were next tried as detectors. Pulses from individual secondary particles produced by gamma rays coming from outside the well casing are "counted" in the G-M counter tube, and amplified by a single battery-operated vacuum-tube stage mounted directly above the counter tube in the logging unit. The resulting strong pulses travel up a cable to a thyratron-controlled frequency meter and a recording galvanometer at the surface.

In these measurements, one of the biggest problems results from the random nature of the radioactive processes. The measured "frequency" is a fluctuating quantity, which must be averaged out over as long a time interval as is convenient. A compromise must therefore be made between the desired smooth, average curve, the ability to detect sudden changes in radioactivity, and the speed of logging. A combination that has proved satisfactory permits logging at a speed of the order of 25 feet of well depth per minute. The frequency of pulses from a counter tube was of the order of five per second at this speed.

COMMERCIAL EQUIPMENT—In more recent work the gamma-ray technique has been adapted to commercial logging equipment. For example, cable having a single conductor, insulated in a steel sheath (used extensively in making electrical logs) is employed instead of multi-conductor cable. Various circuits have been tried in which power is fed down the cable from the surface to the vacuum-tube in the chamber at the same time as pulses are transmitted up to the surface.

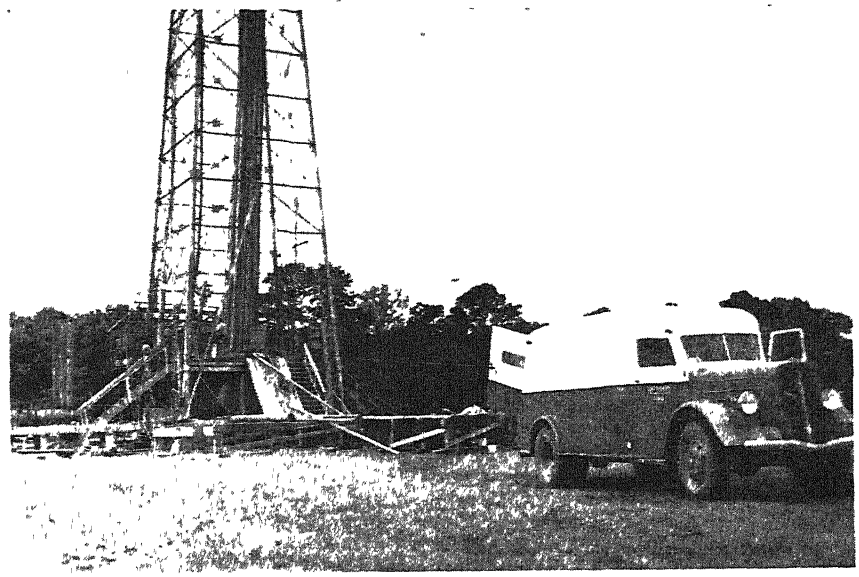
An interesting application of the gamma-ray logging technique has been the tracing in oil wells of cement which has been made radioactive by addition of carnotite ore.

In present-day drilling practice all

casing is set in cement in the well. The cement is pumped down the pipe and up between the wall of the hole and the pipe and it is often important to be able to trace the course and disposition of the cement. When first placed, the cement is easily detected by measuring temperatures throughout the well while the cement is setting, due to the heat developed. Sometimes, however, the cement is forced out under great pressure through holes made in the casing by bullets fired from a special gun. Very often new cement is squeezed out behind old cement, so that the heating effects are not easily detected

By using heavily doped radioactive cement, squeezed cement is easily located by gamma-ray measurements The cement may travel a fairly large distance, as much as 70 feet, along the outside of the pipe Squeeze jobs are usually used in sealing off objectionable water and gas sands from producing sand.

Recent techniques of electronics and nuclear physics have thus given the oil industry a much needed tool for exploring cased wells. At present, it appears that formation logging is the principal application of the gamma-ray method. However, it is not limited to this work or to cementing operations, but is applicable also to the location of any extraneous material introduced into a well, particularly to the location of markers for future operations in the well.



Courtesy Halliburton Oil Well Cementing Company

Truck set-up for making an oil-well log by use of new gamma-ray technique

MUD ANALYSIS—Electronic apparatus is also used in modern mud-logging equipment. While the oil well is being drilled, continuous analysis of some of the chemical and physical properties of the mud used as the drilling fluid is made possible by the application of electronic control equipment especially designed for this purpose. Data obtained enable the geologist and petroleum engineer to arrive at a clear understanding of the conditions in the bore hole and thus they aid in the final completion of the oil well. Drilling mud returned from an oil well which is being drilled by the rotary method, with a circulating mud stream, is being examined under ultra-violet light to determine the presence in the drilling fluid of crude oil. This examination is usually made by taking samples of the mud, subjecting them to rays of an ultra-violet lamp and observing whether or not any fluorescence is emitted from the sample. The fluorescence is supposed to come directly from crude oil. This procedure does not permit of any quantitative determination of the amount of oil in the mud, but is a qualitative method.

A recently developed electronic modification of this technique provides a quantitative method for determining the amount of oil in a drilling fluid. It is based on the discovery that when oil is dissolved in a non-fluorescent solvent the fluorescence of the oil under ultra-violet light is so distributed as to make possible a quantitative light measurement. Solutions as small as one part of oil in a million parts of solvent give a fluorescence which is readily measurable. Typical solvents used are benzol, carbon tetrachloride, ethers, toluene, xylene, and the like. The solvent must be one which is water immiscible.

In one of the simpler forms of the same method, a sample of mud is segregated and agitated with a quantity of the solvent. The solvent, after thorough agitation, is separated from the solids of the sample and placed in a tube or cell where it is exposed to ultra-violet light. The light emitted by fluorescence is measured by any light-measuring device, such as a photocell arrangement. In a more elaborate form, measurements are made continuously and recording of the results is automatic.

In one method of geophysical prospecting, the seismic or artificial earthquake method, the geophysicist, beginning with the use of electronics in refraction seismograph amplifiers for building up the feeble earth impulse resulting from the distant dynamite explosion and in radio equipment for transmitting and recording the instant of this explosion, has come to accept the vacuum tube as a standard part of his equipment in the scientific exploration for oil and gas-bearing areas.

The successful application of electronics in field instruments has overcome the natural distrust of things that are new and untried. At the present time, electronics is applied successfully to instruments used in all the geophysical exploration methods, such as seismic, thermal, magnetic, electrical, and gravitational.

For the past ten years, the reflection seismograph method of geophysical exploration has proved to be outstanding in locating petroleum-bearing properties. By means of seismic pick-ups, high-gain amplifiers, and photographic recording galvanometers of the multi-element type, the seismic effects produced by controlled dynamite explosions are recorded and analyzed. The depths to the reflecting strata are determined from the velocities of propagation and the total time required for the seismic vibrations to travel from the point of the explosion to the reflecting interfaces and back to the seismic detectors located at the surface of the earth. The point of explosion, referred to as the shot point, is commonly located from 50 to 100 feet below the earth's surface.

PHOTOGRAPHICALLY RECORDED—When the seismic waves arrive at the earth's surface, their acoustic energy is converted to electrical energy by means of seismic pick-ups. This energy is then passed to high-gain amplifiers, automatically adjusted to a given level and the undesired components filtered out, and then passed to recording galvanometers where the photographically recorded seismogram is made Timing marks at intervals of 0.01 second and the instant of explosion of the dynamite charge are recorded on this seismogram, together with the seismic refracted and reflected waves.

When such a seismogram is made with a large number of seismic pick-ups placed on the surface of the earth in line with the shot point at intervals of around 200 feet, it is possible to differentiate between the direct, the refracted, and the reflected waves, because of the difference in their apparent velocity of propagation. The time from the instant of explosion of the dynamite charge to some definite reflected or refracted characteristic of this event is counted to the nearest thousandth of a second and the depth to this reflecting horizon is then computed By this means, contour maps can be drawn of the subsurface strata at depths of from a few hundred feet to around 20,000 feet. Carrying the survey over a large area, subsurface anomalies where petroleum might exist may be detected.

The velocity of propagation of the seismic wave depends upon certain properties of the medium through which the wave passes. If hard rocks are involved, the velocity of propagation may be 8000 to 20,000 feet per second. If the materials are soft, the velocity will be much less than this. In some instances, the velocity of propagation through certain shallow formations is even less than the velocity of trans-

mission of the sound wave through air

The instruments employed for seismic pickups that detect the seismic reflections are somewhat similar to the microphones used in broadcast stations. They usually consist of a suspended mass that is connected to the moving element of the pickup. The frequencies of the reflections vary from about 20 cycles up to around 80 cycles depending to some extent on the elastic properties of the deep formations and to a greater extent on the properties of the formation in which the explosion occurs and on which the seismic pickups are located. The frequencies of the direct waves are in general lower than the reflection frequencies, and the frequencies of the extraneous disturbances caused by wind and traffic are usually higher than the reflection frequencies. The usable sensitivity of the electronic equipment is therefore, increased when filter circuits favoring the reflection frequencies are used.

Radio communication is used in preference to telephone lines when the operating truck containing the recording instruments is located a long distance from the shot point or when the intervening area is traversed by wooded sections or streams. Low-power transmitters are satisfactory for this purpose since the distance seldom exceeds five miles. When the charge of dynamite in the hole at the shot point is exploded, the electrical circuit to the cap is broken. The electrical impulse that results from this sudden break of the cap current is impressed on the modulating section of the transmitter and a signal is emitted at the instant of explosion. This signal is in turn received at the recording truck and recorded by a moving-coil galvanometer in the recording unit.

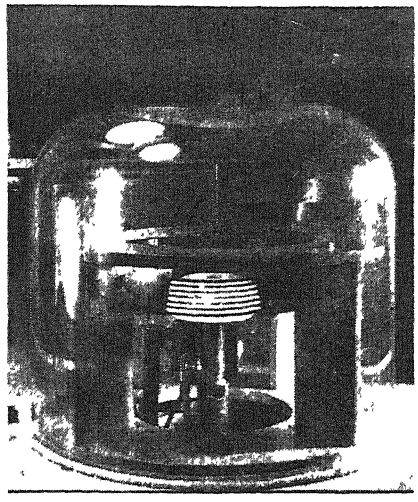
Electronic equipment also plays an important part in talk-back systems used on the drilling rig. Talk-back systems that supply the means for intelligible communication from the fourble board near the derrick's top to the noisy derrick floor decrease the hazards and help coordinate efforts in handling heavy drill pipe

* * *

OIL-WELL DRILL BITS

Are Given Tough Teeth Electronically

OIL-WELL drill bits that bore through solid rock are tough because a layer of tungsten carbide is deposited on the teeth under high temperature. Conventional practice has been to carbide the teeth one at a time with a torch. Recent experiments in the Westinghouse high-frequency laboratory, however, have resulted in carbiding all the teeth at once in a few seconds. This is accomplished by passing the toothed cutter, on which the carbide particles are held by an adhesive coating, into the inductive field produced by a high-frequency oscillator. The heat generated causes



A red-hot oil-well drill bit is hardened in an experimental induction furnace by the tungsten carbide process described in the text

the carbide particles to merge with the steel base. The new method permits the use of protective gas atmospheres to improve the quality of the carbide surface, and can be operated semi-automatically and at high-speed by unskilled operators.

RUBBER SHEET INSPECTION

Accomplished by Electronic Means

PIN HOLES in rubberized canvas sheeting are detected electronically by passing the sheeting between two rollers that are saturated with a conducting liquid. The liquid penetrates even extremely small pin holes in the canvas, forming a conducting path through the canvas and between the rollers. The rollers are insulated from other objects and connected to a vacuum tube amplifier which feeds an electromagnetic relay. This relay may in turn actuate a marking device that locates the defect, or may stop the machine and actuate an alarm.

OCTANE TESTER

Utilizes Variations in Cylinder Pressure

AN ELECTRONIC octane-rating indicator for use with internal combustion engine has proved extremely useful in the development of gasolines having octane ratings higher than have previously been available.

The principle of operation of the instrument depends upon the fact that the ideal internal-combustion gasoline engine operates at a constant rate during expansion of the gas within the cylinder. In an actual engine, the expansion period of the explosion consists of a number of oscillations of rather high frequency, or about 6500 cycles per second, which can cause engine knock and impair efficiency. The octane-rating indicator measures these oscillations during the expansion period.

The instrument contains a pressure-operated pick-up, similar to an electrodynamic microphone, which is inserted in the wall of the engine cylinder so that its diaphragm responds to the variations of pressure. The diaphragm, in turn, induces corresponding voltage variations in an iron-core coil, which are then amplified by vacuum tubes to a suitable level.

An electrical integrator circuit totals the energy variations so that the output of the integrator is proportional to the amount of engine knocking. A meter at the output of the integrator measures this energy, and is calibrated directly in octane rating by burning fuels of known rating in the engine cylinder.

POWDER SEPARATOR

Operates on Electrostatic Action on Materials

CERTAIN dry, powdered materials may be separated from each other by electrostatic action In the chemical field, for example, among the materials which may be separated in this manner are sphalerite and iron pyrites, graphite and mica; biotite micas and muscovites, garnet and metal particles These materials have essentially different electrical characteristics and this difference provides a means of attack.

The electrically unlike materials to be separated are passed over or between electrodes charged to about 15,000 volts D C. One material picks up and retains a charge, in its passage over or between electrodes, sufficient to cause it to adhere to an electrode. The other material flows unimpeded through the separator to a collecting hopper High-voltage D C. to operate such separators is readily obtained by stepping up A C power-line voltages through suitable transformers and then rectifying electronically

DEW POINT METER

Controls Moisture in Natural-Gas Pipeline

TO PROTECT gas lines from clogging due to freezing when moisture condenses inside them in winter months, a dew-point recorder using a photoelectric relay is employed at the point where the natural-gas pipeline from Texas enters the metering plant in Denver, Colorado. Whenever the continuous recordings show that the dew-point is high enough to cause freezing, instructions are dispatched to dehydrating plants to remove moisture before trouble occurs.

Part of the gas is routed through a U-shaped tube having a mirror inside each corner, with a light source at one end of the tube and a phototube at the other. The tube is immersed in an anti-freeze solution that is alternately refrigerated and heated. Chilling causes moisture in the gas to condense on the mirrors and reduce the amount of light reflected into the phototube, while heating drives off the condensation and restores full illumination. Associated electronic equipment converts the phototube output and temperature readings into desired dew-point indications.

Modern Lubrication

For Centuries, as Long as Lubrication was on an Empirical Basis, its Efficiency Remained Very Low. Only When a True Understanding of the Basics of the Lubrication Process was Reached Could Bearings and Lubricants be Designed to Make Possible Today's Machines

By E. M. BARBER
Beacon Research Laboratory The Texas Company

THE PRESENT era of our civilization depends very greatly on the continuous and reliable operation of countless numbers of machines, most of which are characterized by motion between two surfaces pressed together by comparatively large forces. Correct lubrication of these moving surfaces is essential to the continuous and reliable operation of the machines.

Without lubrication, or with inadequate lubrication, much of the energy of the machine may be dissipated as friction of the moving surfaces, leaving little excess of energy to do useful work. In addition, the wear at these surfaces may be so great that the machine will become inoperable in a very short period of time. With the best lubrication methods known, the friction loss is but a small fraction of the total energy output of the machine and wear can virtually be eliminated.

THEN AND NOW—Familiar examples of the machine processes on which our civilization depends are: A shaft rotating in the bearing of a steam turbine or in a vacuum cleaner; a piston moving back and forth in the cylinder of an aircraft engine or a cross head moving back and forth in its guides in the engine of a Liberty ship; a wire passing through a die in a wire mill; or a tool cutting metal to form gun barrels. All these familiar machine processes depend on lubrication for continuous and reliable operation.

In its earliest recognized and most elementary form, lubrication consisted simply of putting some form of film between the parts that are in relative motion, thus reducing friction and wear. Apparently the earliest machine builders recognized the necessity of providing some form of lubrication for their machines, and recognized further the special value of various oils, fats, and greases for this purpose. Indeed, historians report references to the use of animal, vegetable, and mineral oils among the earliest written records. They report, also, that the mechanized armies of 1400 B.C. were especially partial to the use of beef and mutton tallow for the lubrication of their chariot wheels. From the crude machines and lubrication practices of these early times to the modern machines of peace and war is a long step; moreover, it is a step that was not and could not be taken until the nature of the lubrication process was understood well enough to release the machines from their burdens of friction and wear.

Until the latter part of the 19th Century, lubrication theory and practice were still at the stage where machines commonly used as much as half of their energy to overcome their own friction and therefore wore out very rapidly. With the high friction forces that were characteristic of the lubrication methods even of that date, some of our more interesting new machines, like the gas turbine, could not have operated.

Finally, in the 1880's, partially as the result of a lucky accident, partially as a result of a brilliant theoretical analysis, a real understanding of the nature of the lubrication process was obtained. With that knowledge as a basis it is possible now for engineers to design bearings and select lubricants so that friction can be reduced to a small fraction of the total power of the machine and so that in many cases, at least, wear virtually is eliminated. It is true that much remains to be learned about lubrication but what is known already serves as a firm basis on which to build the future development of even better mechanical servants of our civilization.

The historical record of how this information was obtained is a fascinating case history of the scientific method in operation and gives, also, one of the best backgrounds for understanding the nature of the lubrication process.

CLASSIC EXPERIMENTS—In 1883, Beauchamp Tower reported to the Institution of Mechanical Engineers the results of friction experiments made on bearings similar to those used in railway cars. The effect on friction of the method of supplying the lubricant was of particular interest in these experiments. Therefore, a large number of arrangements for oil supply were tried. One method, that of immersing the lower part of the shaft in a bath of oil, was found to reduce friction to a fraction of that effected by other methods then in common use for the lubrication of machinery.

Toward the end of the group of experiments with bath lubrication, Tower made a further important discovery A hole had been drilled through the center of the bearing, at the top, to accommodate a lubricator for use in subsequent experiments. When the machine was started, still using bath lubrication, oil began to flow out of this hole. The machine was stopped and a wooden plug was driven into the hole, but when the machine was restarted the plug was forced out of the hole and again oil flowed from it.

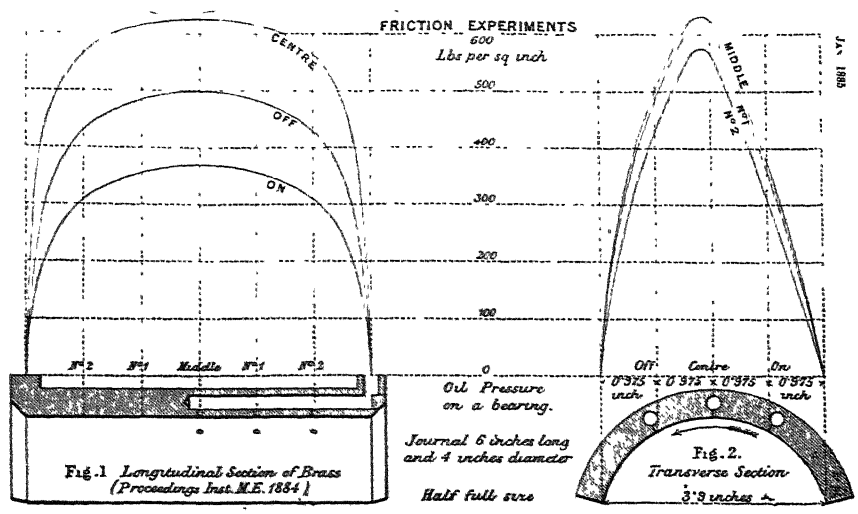


Figure 1: An illustration from Tower's famous paper

This appears to have been a critical moment with regard to our knowledge of lubrication. If Tower had successfully plugged this hole, our understanding of the lubrication process probably would have been retarded for many years. Instead, however, Tower applied a pressure gage to the hole and restarted the test. Very shortly afterward, the pressure was seen to be so great that it exceeded the range of the gage, which was capable of measuring pressures only to 200 pounds per square inch.

A CORNER TURNED—This experiment gave the first evidence that pressure could be created by the oil film of a bearing. In subsequent experiments, also employing bath lubrication, several holes were drilled in the bearing. On applying pressure gages of suitable measuring capacity to them, Tower found that the pressure at each hole was different, being zero at the edges of the bearing and greatest at the center. The pressure observed at the center hole was found to be greater than the unit load, or load per unit of bearing area, on the bearing; it was 625 pounds per square inch in one case when the unit bearing load was only 330 pounds per square inch, and the pressure increased or decreased when the load on the bearing increased or decreased. The resultant of the pressures, measured at the various holes of the bearing surface, was found to equal the load on the bearing.

Figure 1 is reproduced from Tower's report and shows how the holes for pressure measurements were located, and also gives some of the pressures that were observed.

The Scottish engineer, Osborne Reynolds, was greatly interested in Tower's experiments, particularly in the observation of pressure in the oil film and in the exceptionally low friction when these pressures occurred. To Reynolds these observations meant that, in some way or other, a pressure was built up in the film which caused the two surfaces to be separated so that they were floated by the lubricant; the pressure automatically adjusted itself to carry the load applied to the bearing and the friction was only that of the fluid in the oil film.

As a result of his interest, Reynolds undertook a theoretical study of the manner in which oil could flow in a narrow space between two surfaces in relative motion, one surface representing the rotating shaft and the other the stationary bearing that surrounds the shaft. In 1886 Reynolds published the results of this study, and our present understanding of the lubrication process is derived largely from that publication. Reynolds' study showed that there could be two domains of lubrication. One the "imperfect" or "boundary film" region, which is characterized by relatively high friction and wear caused by limited metallic contact between the moving parts. The other, which has come to be known as the domain of "fluid film" lubrication, is characterized by very low friction in which wear is virtually non-existant since the surfaces are entirely separated by a fluid film of the lubricant and no metallic contact exists. Reynolds went even further than to explain Tower's results and derived a very exact description of the lubrication process and of the conditions essential to obtaining fluid film lubrication.

According to Reynolds' description of fluid film lubrication, the lubricant is considered to be drawn into a wedge-shaped space between the bearing and shaft where, owing to its viscosity, the lubricant produces forces—the so-called viscous forces—which account for the load-carrying capacity and friction of the bearing. This description is the accepted theory of how a fluid lubricated bearing operates. According to it, the viscosity of the lubricant and its ability to wet the surfaces that it contacts are the essential characteristics of a lubricant.

Viscosity is a measure of the resistance offered by a fluid to a change of shape or to relative motion of its parts. It has been described as "what molasses has a great deal of in January." Viscous liquids such as molasses offer strong resistance to change in shape whereas less viscous liquids such as water offer much less resistance. Mineral lubricating oils having almost any desired degree of viscosity can be obtained. The ability to wet surfaces that they contact is characteristic of all lubricating oils. For example, a lubricating oil poured on a metal surface spreads across the surface and is difficult to wipe off, whereas mercury poured on a metal surface remains in the form of a small globule and will roll across the surface freely. The oil is an example of a wetting liquid, mercury is an example of a non-wetting liquid.

With the properties of viscosity and surface wetting in mind, we can now return to a study of the action of the lubricant between two surfaces in relative motion and follow Reynolds' ideas of how this action is related to the load-carrying capacity and frictional resistance of bearings.

Figure 2 shows two parallel surfaces, slightly separated, one surface, *AB*, being stationary while the other surface, *CD*, moves parallel to *AB*. Both of the surfaces are immersed in lubricant. Because of the wetting properties of the lubricant, fluid particles in contact with the stationary plate will remain fixed to its surface and fluid particles in contact with the moving plate will remain fixed to it and move with it.

TO DEMONSTRATE—If the surface *CD* is considered to have moved so that point *E* has moved to the point *F*, then the fluid particles at *E* will have moved to the new position *F* but the particles at *A* will have remained at *A*. The intermediate fluid particles that initially lay along the line *AE* will have been drawn into the new position *AF*.

Obviously, the triangle *AEF* will represent the quantity of lubricant that was drawn into the space between the two surfaces by the motion *EF* of the upper surface, and the equivalent triangle *BGH* will represent the quantity of lubricant that flowed out from between the surfaces. By this movement the rectangle *AEGB* has been transformed into a parallelogram *AFHB* and its shape has therefore been changed. The viscosity of the lubricant resists this change of shape, and force must be applied to the upper plate *CD*, proportional to the rate of change of shape, in order to overcome these viscous forces. This force required to move the plate *CD* corresponds to the force of friction.

This is the condition of flow of a fluid which Reynolds first visualized, and it explains the origin of the friction forces but it does not tell us why the

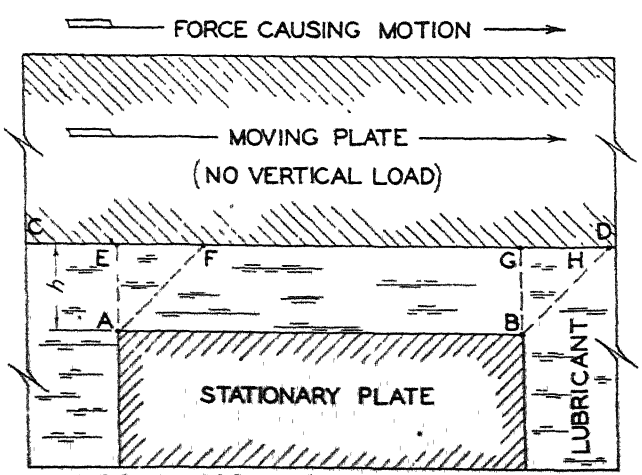


Figure 2: Behavior of lubricant between moving surfaces

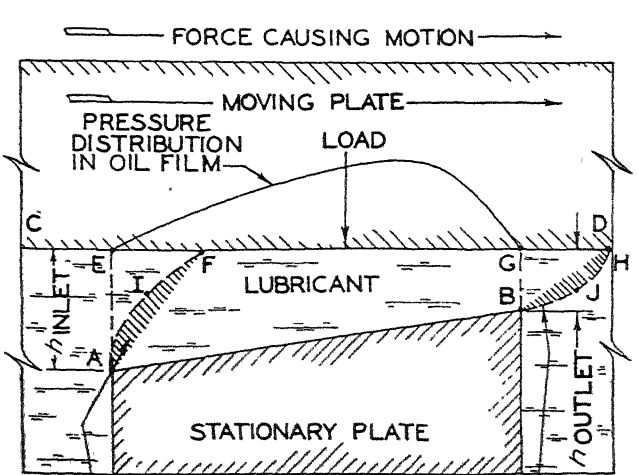


Figure 3: Why the moving plate doesn't rub the fixed plate

moving plate should remain separate from the stationary plate when they are forced together by a load.

If the two surfaces had been slightly inclined, instead of parallel, as shown by Figure 3, the space between them would be wedge-shaped and more lubricant would tend to be drawn into the space across *AE* than can flow out across *BG*. This, however, is impossible What happens is that the forces due to viscosity attempt to wedge more fluid into the clearance space than can get out and, in consequence, pressure develops in the film, the pressure having a distribution similar to that indicated in the curve at the top of Figure 3. This pressure decreases the inflow at *AE*, and increases the outflow at *BG;* with the result, shown by the figure, that the inflow occupies a new area *AEFIA* and the outflow is increased to an area *BGHJB,* both of which are equal. As in Figure 2, the motion of the surface *CD* is resisted by viscous forces of the lubricant and these forces are the source of friction of the bearing. These same viscous forces produce the pressure in the oil film which tends to keep the two surfaces separated despite the fact that they may be pushed together by a large external force.

It is not clear at first that the wedging of the fluid into the space between the surfaces by the relatively weak viscous forces can lead to high enough pressures to account for the known ability of bearings to carry loads of hundreds of pounds per square inch However, the sketches drawn to show the flow of liquid are of necessity exaggerated and create a somewhat erroneous impression of the operation and inclination of the surfaces. In an actual bearing, the separation of the surfaces at *BG* might be 0.0005 inch and the inclination (excess of *AE* over *BG*) 0 0002 inch in a length *AB* of several inches, so that the effect is that of a very flat wedge giving a tremendous mechanical advantage. Thus it is apparent that the production of pressures sufficient to support very large loads is much more reasonable

The foregoing has explained the lubrication process in terms of flat surfaces. These, however, though important, are encountered in lubrication practice less frequently than cylindrical surface bearings. Fortunately, it is possible to apply the ideas developed in connection with flat bearings directly to cylindrical surface bearings. As shown in Figure 4, for a cylindrical bearing the moving surface *CD* of Figures 2 and 3 has been changed into a circle so that it becomes the shaft, and the stationary surface has been changed into a slightly larger circle so that it becomes the bearing. The wedge-shaped passage between the surfaces

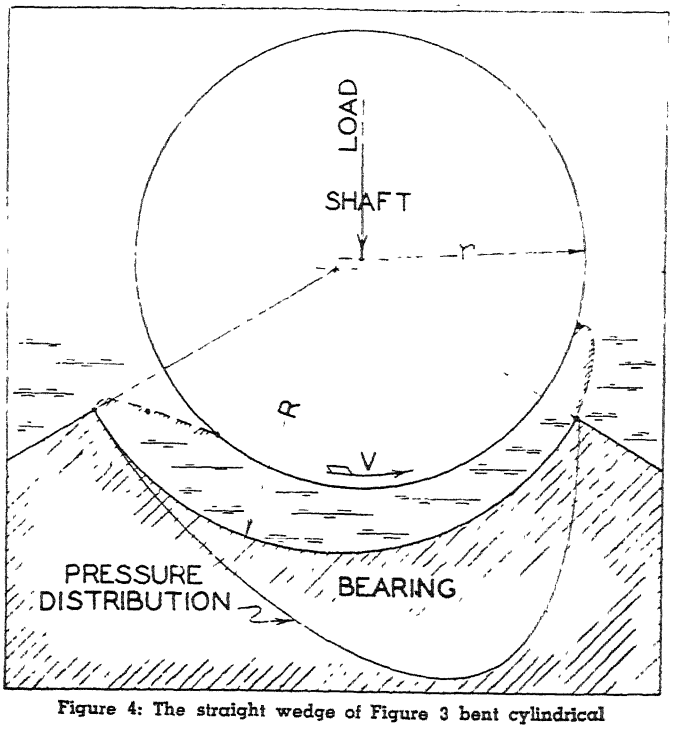


Figure 4: The straight wedge of Figure 3 bent cylindrical

results from the fact that the bearing is made to have a few thousandths of an inch larger diameter than the shaft and the shaft runs with its center displaced from the bearing center. The wetting action of the lubricant, combined with the viscous force, causes pressure to be developed in the clearance space between the shaft and the bearing and the resultant of these pressures supports the shaft on a fluid film. The frictional resistance to rotation of the shaft is only the resistance required to overcome the viscous forces of lubricant in the clearance space

IN SUM—The continuous and reliable operation of the machines which are so essential to our modern way of life depends very greatly on our ability to lubricate their rubbing surfaces so that they develop the least possible friction and thus insure a minimum of wear. Very low friction and virtual elimination of wear can be obtained by operation of these rubbing surfaces under the condition of fluid film lubrication. It has been seen that two physical conditions essential for producing fluid film lubrication are: (1) That there be an adequate supply of lubricant of proper wetting power and viscosity available at the bearing plate, and (2) that the rubbing surfaces be very nearly perfectly formed and so disposed that they form a proper wedge-shaped passage for the oil flow between them.

The theory of fluid film lubrication, founded by Tower and Reynolds and expanded by many other individuals, gives much practical information for the realization of the two necessary conditions listed above. In a given problem where, for example, the load, speed, overall size, and surrounding temperature are specified for a bearing, it is possible to select an oil of the correct viscosity characteristics and to specify the geometric features of the load-supporting oil film from theoretical considerations. The latter information determines how much larger than the shaft radius the bearing radius should be, the positioning of the bearing surface with respect to the load, and the minimum distance of separation of the two surfaces when the bearing is operating. Such analysis involves consideration of the heat generated by the fluid friction and its dissipation, and it allows computation of the frictional losses. For the suggested problem many solutions are possible. The desired solution will be one in which the variables under control are selected to give the least possible friction consistent with the desired bearing safety as measured by minimum film thickness By guiding a machine designer in these matters the theory of lubrication renders an invaluable service.

Practical knowledge born of accumulated experience and countless experiments has added to the information at the disposal of the bearing designer and aided him in the solution of the ever more difficult problems arising with the advent of new, more efficient, and more compact machines. Lubricants have been developed for special applications; bearing materials have been found which give optimum service for severe conditions of operation; improvements have been made in surface finishing so that film thicknesses may be decreased and higher loads carried; practical knowledge of good methods of introducing and handling the bearing lubricant has been accumulated; and the information furnished by theory has been extended by experiment to fit situations too difficult for analysis alone.

For example, it is now possible to select lubricants that are satisfactory at extremely low temperatures, or that show exceptional stability with respect to oxidation. Oils may be had which aid remarkably in keeping an engine clean or which separate from water with exceptional readiness. In some cases it is important to have a lubricant which mixes well with water and forms an emulsion. Such lubricants are manufactured. The advances in lubricant technology could be listed almost without number, but before leaving this subject it may be well to stress that the most important contribution of the petroleum industry to the practice of lubrication has been the supply of graded lubricants over a wide viscosity range in practically unlimited quantities.

The development of bearing materials and construction have been of equal interest. Diverse examples ranging from the oil pads that support a giant telescope to tiny pivot bearings of instruments may be studied. The telescope bearings move at practically zero speed under heavy load; the tiny pivot bearing often with very light load, at high speed, and with little friction.

Aviation Surveyed

Aircraft Production, Materials, Tools, Transportation, Airports, Safety, and Design, as Viewed by an Observer at the Annual Meeting of the Institute of Aeronautical Sciences. Why and How the United States Has Achieved Military Supremacy in the Air

THE ANNUAL meeting of the Institute of Aeronautical Sciences is always the most significant aviation event of the year; the most recent meeting was no exception to this rule. A large number of papers were read and discussed, covering the entire field of aeronautics from Aerodynamics to Production and from Power Plant to Metereology. The following paragraphs will describe as fully as possible the most outstanding of these papers.

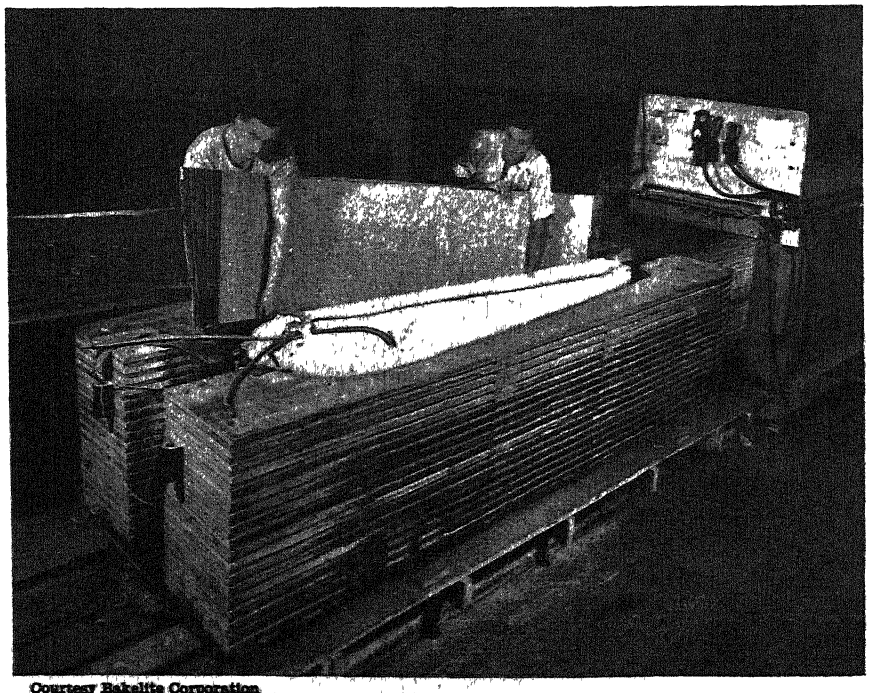
Perhaps the most important reason for our present supremacy in the air as compared with Germany is the fact that we have been able to pursue research and development in all branches of aviation, whereas the Germans, partly by design and partly by necessity, have more or less standardized their airplane designs. This was fully recognized by General Henry H. Arnold, Commanding General of the Army Air Forces, who, accepting an honorary fellowship offered to him by the Institute, said: "It is through the work of theorists and experimenters that we are better than our enemies, not merely man for man but plane for plane."

The first meeting of the conference was appropriately devoted to Aircraft Production—the most vital national task today. In the construction of aircraft, the aviation industry has drawn on the help of almost every other American industrial skill—tool making, machining, casting, wood working, metal pressing, heat treatment. But the construction of aircraft has called for so much that is new, and for such high tolerances and standards, that these methods and processes have been greatly advanced. Thus aviation will make a more than sufficient return to other American industries for their help.

FLYING WOOD—Robert H. Hess, of Curtiss-Wright Corporation, in "The Trend of Wood Use in Aircraft" presented facts that apply to all wood construction. The British have built in wood the famous and successful Mosquito Bomber, and the Russians have an all-wood single-seater fighter, the Lagg-3, which has a maximum speed of over 360 miles an hour. But the United States has built only gliders and training planes in wood and plywood, and there is strong opposition here to the use of wood in combat aircraft. This opposition is due not so much to the inherent limitations of wood as to our lack of knowledge in handling it.

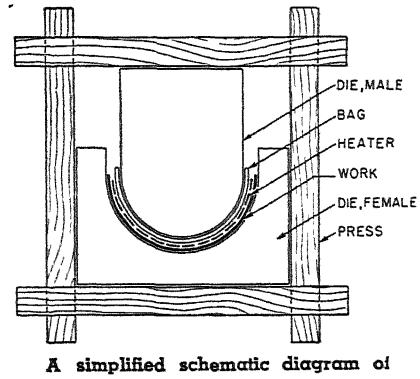
Perhaps the greatest deterrent to the use of wood for aircraft lies in the fact that most engineers have had little or no training in its use. Another difficulty lies in the lack of data on its strength and elastic properties. We have far more knowledge of steel, aluminum, or even magnesium than we have regarding wood—in spite of the fine work of the Forest Products Laboratory. The wood industry, if it wishes its products to be accepted in an engineering sense, has to become research and technical minded to a far greater degree than heretofore.

Then there is the problem of stress concentration in wood at points where bolts and fastenings are used. Wood is probably stronger in tension than steel, if its weight is taken into account, but its compressive and bearing strengths are sometimes inadequate. Still another difficulty with wood structures is caused by the fact that they absorb moisture readily, under which conditions dimensions and strength are likely to change. When the moisture content of plywood is not strictly controlled, wrinkles appear on large unsupported panels, fittings loosen, and weight increases inordinately. The moral here is that for wood manufac-

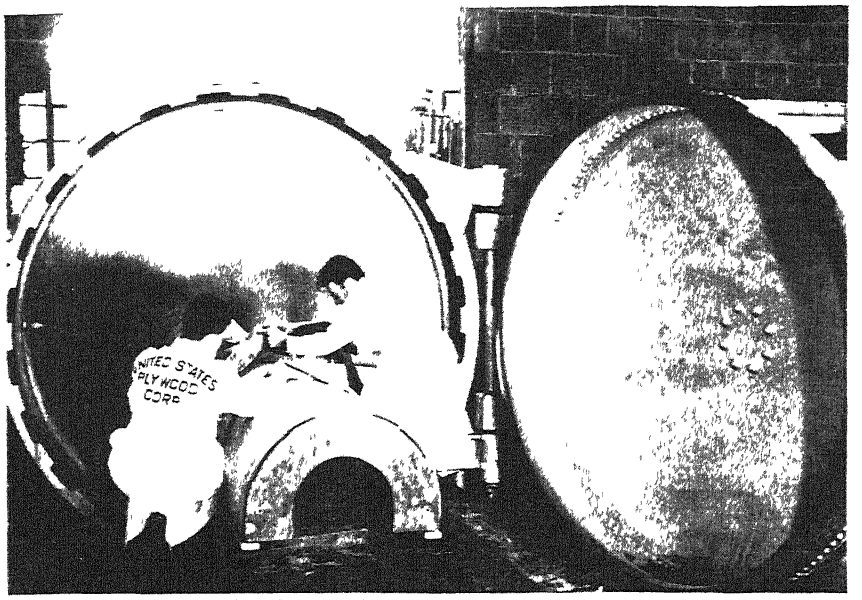


Courtesy Bakelite Corporation

Twin wooden dies used in producing curved shapes in plywood



A simplified schematic diagram of plywood molding by the Thaden bag process, using male and female dies



Courtesy United States Plywood Corporation

Preparing a plywood unit for molding in a large autoclave

ture there must be found methods of close air control or conditioning during construction, and protection against moisture by suitable surface finishes or coatings after fabrication. Here is something for the air conditioning people to think about, and perhaps another opportunity for this industry in the post-war period.

On the other hand, there are some very encouraging factors in the wood situation. First there is the tremendous improvement in glues. These new adhesives have eliminated the dangers that arose from glues of animal origin —fish, bone, or milk. The urea-formaldehyde, phenol formaldehyde, and other synthetic resins resist the action of bacterial growths, withstand moisture better, and give a far stronger bond. Also, by skilful handling, they allow steel to be bonded to wood and plywood—a development which has great significance in many industries besides aviation.

BAG MOLDING—With these splendid new adhesives have come methods of bonding at not too high temperatures, and the now famous bag molding process. With bag molding it is possible to form complicated compound curves cheaply and quickly Still another modern advance is so-called densified wood. By compression and resin impregnation of wood, materials are available with high specific gravity, with strengths close to that of mild steels, and offering manifold possibilities.

In aircraft inspection, the Magnaflux method for testing ferromagnetic materials for cracks and other defects has now become standard. Speaking about this work, M. Mages of Magnaflux Corporation disclosed an improvement welcomed in aircraft production, but equally important to other industries concerned with the handling of ferromagnetic materials. Thus the Magnaflux method is widely used for the inspection of gun mounts, turbine blades, high-pressure piping, and a variety of welded structures, and for other ferromagnetic parts which receive severe handling during manufacture or in service. The testing of iron or steel by the Magnaflux method consists essentially of magnetizing the part under test by means of a coil, or by passing current directly through the part and applying an indicating medium such as a suspension of finely divided magnetic materials in a light oil. If there is a crack or discontinuity in the materials the magnetic leakage field formed across the crack attracts the magnetic particles suspended in the oil and a greatly magnified outline of the crack is formed.

Another process of great general value—"Plastic Tooling"—was discussed by Leonard Weiss of the Brewster Aeronautical Corporation. The outstanding features of plastic tooling are that tools may be cast in plastic to a master part, model, or mold, more quickly than by forming, milling, or hand fitting; duplicate tools may be fabricated at less cost than the original because the molds can be saved and reused. Businessmen and manufacturers will do well to pay attention to these possible advantages.

Some definitions given by Mr. Weiss will make the subject more clear.

Cast Plastics embrace those materials which can be cast around a contour. This type includes such materials as thermoplastics, thermo-setting resins, inorganic cast compounds, cements, and low melting point metal alloys.

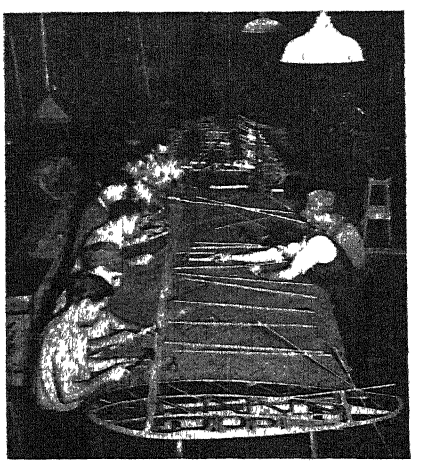
Conventional Tooling covers those tools which are made by the usual methods of laying out and hand work, employing various machines and materials which have to be shaped by cutting or hogging-out.

Plastic Tools include those types which are made by casting a material around a shape, with the aim of reducing finishing operations to a minimum. This includes castable materials, such as plastic resins, low melting point alloys, and so on.

Real interest attached to the paper on "Traffic Control for Future Airports," by M. G. Beard of American Airlines, since one of the difficulties in air transport, recognized both by the specialist and by the layman, is that of traffic control. Airline traffic, even before Pearl Harbor, was fast reaching the saturation point—at La Guardia Airport, for example. Thus, on December 1, 1941, there were 248 scheduled departures and arrivals at this airport. During the peak of the day—5:30 to 6 30 P.M.—there were 40 plane movements during the hour. Shortly after 5 00 P M. it was not unusual to see 12 to 15 planes waiting in line for their turn to take off. Whenever ceilings went below 1600 feet, with visibility below three miles, it became necessary to institute low-approach procedures, and, the resulting traffic delays and tie-ups would frequently detain arrivals from three to four hours

One can imagine what the situation may become after the war. Surveys of post-war traffic indicate a possible expansion many times greater than anything experienced heretofore, yet airport traffic facilities and control methods have almost reached the saturation point now. Present radio-range systems of navigation are probably adequate and present methods for instrument landings, with some improvements, may be made satisfactory. But to realize the full potentialities of these two systems will require "immediate methods of coördinating radio-range flying with approach landing systems." This is what Mr. Beard advocates: "The application of radio and radar aids now in existence in war-time application appears possible of adaptation for the solution of the traffic control problem both along traffic arteries and around central airports." Radar, stimulated by war, may yet play a great peace-time role

AIRPORT SIZE—However well our airways and airports may be controlled. the fact remains that we shall have to build bigger and better airports. A. L Morse, of the Civil Aeronautics Administration, has studied this problem and presented his findings in "The Correlation of Aircraft Take-Off and Landing Characteristics with Airport Size." With larger, heavier, and faster airplanes has come the need for paved runways of greater and greater lengths There has also come the need for restricting the height of structures in the



The plywood skin of an airplane wing panel being applied in one of the Fairchild aircraft plants

areas surrounding the airport Both of these necessities have combined to place heavy burdens on the Federal Government and on the municipalities and have made it very difficult to find sites.

In the discussion of airplane design at the Institute meeting, relatively minor topics were taken up but each had its significance in the scheme of things. Thus Albert A Arnhym advocated strongly the soundproofing of military aircraft. It was originally thought that soundproofing and comfortization of the airplane was of interest only in civil aircraft The war has completely disproved this notion. Military and naval pilots do not always go up for only short spells of violent fighting activity where the thrill of battle eliminates all thought of comfort, they go also on bombing missions of many hours' duration. Noises may then become an intolerable burden. The modern view is that military airplanes should be soundproofed with just as much care as the passenger transport. Noise should be diminished first at the source by muffling, gearing down the propeller, and so on, and then should come soundproofing proper, with the installation of suitable material to impede transmission and increase absorption of noises once they have penetrated into the cabin

SAFETY ALOFT—To avoid aircraft accidents, non-stall, non-spin airplanes must be designed, because spinning is responsible for 40 percent of fatal accidents. There are many other items of plane, engine, accessories, landing field, and the like, which must be taken into safety considerations Yet Dr. Hugh De Haven of Cornell intimates that accidents will happen, no matter what is done, and that when the accident does happen specialized design of the airplane can give a fair measure of protection, often replacing fatal injuries with minor mishaps. The fuselage should be rugged, resilient, and not of the eggshell monocoque type which may collapse completely in a crash. Seating should not be too far forward and should be such that the occupants are not involved in the first violence of a head-on crash Human heads should not be in the vicinity of projecting instruments on the dashboard. Biomechanics, the study of the mechanics of the body, is being applied to the airplane and, if the findings of the physiologists are given attention, a good many details of airplane design can be readily changed with a great increase in airplane safety.

Many other ideas presented before the Institute can be mentioned only in flashes:

Pilots can be trained for night flying in the daytime by a new technique which consists of covering the windshields and windows of the plane with green acetate and having the pilot-trainee wear red goggles. Under these conditions the pilot's vision beyond the cockpit is cut down by the combination of both filters so that it approximates night vision. The instructor does not wear red goggles and so he can see beyond the cockpit and enjoy daylight. The new technique adds safety and lengthens the hours possible for night training.

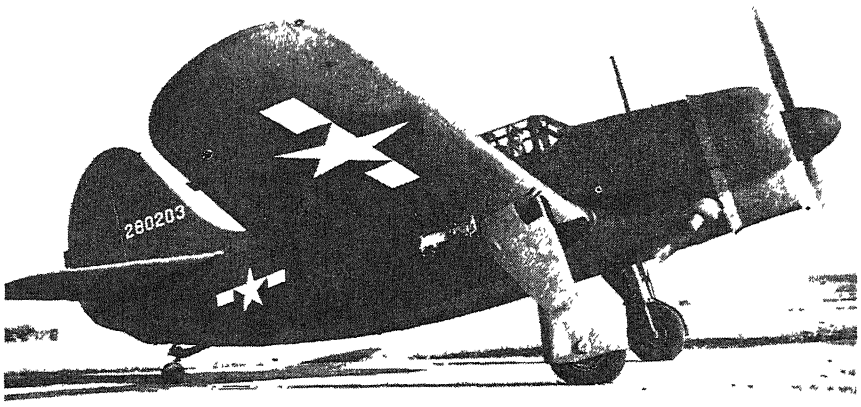
The supercharger is now controlled by an entirely automatic electronic device which is invaluable in high altitude work.

A governor combined with the variable V-belt principle is likely to give us a constant-speed propeller suitable for the light plane—low in cost and light in weight.

It can now be demanded that airplane propellers be both feathering and reversing. The reversing propeller is particularly useful for securing short landings and for maneuverability of a seaplane on the water.

Panel heating by radiant energy which does not heat the air surrounding the occupant of an aircraft cabin, but radiates heat to his body, will make him much more comfortable and will also require far less expenditure of heating energy.

CONCLUSION—When the meeting of the Institute of Aeronautical Sciences is reviewed, as it just has been, it is realized that the most important developments of the day were not even mentioned—the gas turbine, the jet-reaction motor, the airplane of close to 450 miles an hour, the wing that is immune from the compressibility burble, and so on. The only conclusion that can be drawn from this is that our engineers and research workers are doing much more than they are now able to tell and that the end of the war will bring astounding disclosures



Main bomb supply of the Helldiver is carried within the fuselage

ATTACK-BOMBER

Incorporates Lessons Recently Learned in Combat

THE Curtiss Helldiver (A-25), now being delivered to the Marines for use in the Pacific, incorporates all the lessons learned in recent combat. It is a two place, all-metal, low-mid-wing monoplane, which carries its main bomb-load wholly within its fuselage, with provisions for carrying additional bombs under the wing. It mounts four fixed machine guns and an additional gun in the rear cockpit turret. The Helldiver weighs more than 7½ tons, is powered by a 14-cylinder Wright Cyclone, and uses a Curtiss three-bladed electrically operated constant-speed propeller. In the photograph may be seen the opening into which the landing gear retracts in flight. The engine exhaust outlet is of the type which gives some forward thrust by virtue of jet reaction.

POST-WAR FLYING

Will be Safer, Cheaper, For Private Flyers

IN A paper presented before the Society of Automotive Engineers, William D Hall, Chief Engineer, Aeronca Aircraft, discussed post-war private flying and planes—subjects in which both the public and the industry are vitally interested.

According to Mr. Hall, we may expect (1) a low-powered trainer, side-by-side or tandem, to cost $1000; (2) A two-place, medium-performance aircraft for the private owner priced at $1500; (3) A four-place ship at $3000, also of medium performance; (4) A high-performance, two-seater at $3000, which will be a "cleaned up" version of the pre-war two-place, side-by-side, low-wing, retractable gear design.

Standards of design will be much higher than pre-war. We may expect many safety features and, in particular, elimination of the stall spin, which says Mr. Hall, will be accomplished by the following means: "The wing proper will be designed so that it stalls gradually with the stall originating over the center portion of the wing, and the ailerons used will not stall the remainder of the wing when they are deflected to obtain lateral control. Further, longitudinal control will be limited so that it will be impossible to place the airplane in a complete stall position without a dive and a violent pull-up."

Mr. Hall also thinks that the average user will be satisfied with a two-control airplane (aileron and elevator only), even if the maneuverability is somewhat reduced thereby. Accessories such as flaps, slots, and spoilers will be used where occasion demands and will be automatic in operation wherever possible.

By-Passing the Sheep

An Artificial Fiber, With Many of the Best Characteristics of Wool, Is Now Being Made Commercially from Soybean Protein. How it Will Compete With Other Fibers in Price and Uses is Still for the Future to Decide. Tests Made Thus Far Indicate Interesting Possibilities

By H. R. DRACKETT
President, The Drackett Company

FOR HUNDREDS of years sheep have been contentedly munching nature's provender, running it through their digestive systems, and converting its proteins into wool fiber in some manner as yet unknown both to sheep and to man. But now man has been able to go the sheep one better. He has learned to feed protein into a machine, let the machine do the digesting, and subsequently extrude the protein into long filaments which, after chemical treatment, become man-made non-animal protein fibers. Not only has man thus been able to do with proteins one of the things the sheep does with them, but in the conversion he does a much more efficient job.

This newest man-made fiber is processed from the protein of soybeans and its manufacture is believed to be one of the first successful attempts in the direction of freeing man from the expensive and inefficient process of converting the protein in feed into fiber via the digestive mechanism of the animal.

Man's job is virtually 100 percent efficient in this conversion, while the sheep by comparison is frequently not more than 1 percent efficient when it converts its food intake into dry protein product. Consequently, the development of this first non-animal protein fiber becomes of more than casual importance. It is in many respects a fundamental scientific development of far wider significance than would be the mere development of a new textile fiber with a potential field of usefulness of large dimensions.

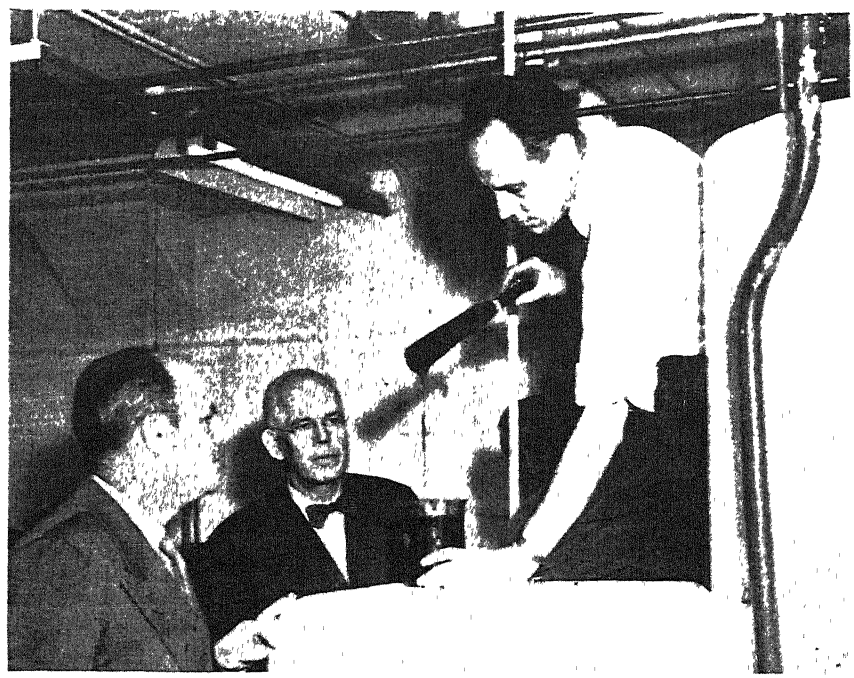
The new soybean fiber should not be viewed as a substitute for wool, cotton, rayon, or any other fiber. It is actually an entirely new raw material. It has virtues peculiarly its own. It will ultimately find its own niche in a competitive field and will be accepted on its own merits and on a true economic level with other fibers in a free market.

In appearance the soybean fiber which is currently being manufactured on a limited commercial scale is a loose, fluffy mass with an appearance similiar to that of scoured wool. Its color varies from a light tan to white. It has a medium luster somewhere between those of wool and mohair. It has a rather warm, soft feel, a natural crimp, and a high degree of resiliency. It is not so strong as wool but in the laboratory batches of it have been experimentally produced which are even stronger than wool. It is possible that fiber which has such increased strength will ultimately be made in commercial production.

Soybean fiber keeps its strength well either wet or dry. It can be blended with other fibers or it can be woven or spun by itself. It has already been made experimentally into blankets, hosiery, rugs, carpets, upholstery, underwear, hats, and suitings—among other things.

NOT A SYNTHETIC—This fiber is by no means a synthetic yarn, any more than it is a substitute. No other material has been synthesized in its manufacture. The fiber had its genesis in a laboratory, as did many other man-made yarns. It owes its origin to the fact that those persons who furthered its development adopted an entirely new concept of the 4000-year-old soybean, looking upon such things as soybean oil and meal not as end products but as the starting points for new chemical developments.

Most Americans think of the soybean as a staple agricultural product of the Orient which has for centuries helped the Orientals keep body and soul together. They fail to realize the place this amazing and versatile bean has gained for itself both in American agriculture and in American industry In 1943 the United States grew more than two hundred million bushels of soybeans, making this the third largest cash grain crop in the country. Yet, back in 1930 the total production of soybeans in this country was almost negligible



Inspecting a batch of liquefied soybean protein which will shortly be forced through tiny holes in a spinnerette at the plant of the Drackett Company in Cincinnati. It will emerge as soybean fiber. Shown in the center is the author of the accompanying article; at left is Robert Boyer, company director of research

The soybean has many virtues. It is very easy to grow, it does not cost much to produce, the beans lend themselves well to mass-production harvesting machinery, and they can be easily and conveniently stored. But in many ways more important than any of these features is the fact that soybean protein is the cheapest and most abundant source of vegetable protein in the world. The 1941 crop, for example, would have yielded about a quarter of a billion pounds of protein if it had all been processed for that purpose. Potentially this is the starting point, the raw material, for many industrial developments.

It was recognition of this huge available source of protein that led indirectly and somewhat circuitously to the production on a commercial scale of soybean fiber. For decades man has sought to duplicate in various ways nature's manufacture of fibers. Silk was once a costly luxury. As far back as the early 18th Century a French scientist developed a process whereby a solution made from gums and resins was forced through a small orifice and coagulated to form a silk-like thread.

OTHER YARNS—In 1884 the French Count Hilaire du Chardonnet patented a process in which a solution of mulberry leaves was drawn through fine glass tubes to emerge as hairlike threads that hardened on contact with air. Du Chardonnet had spent 20 years in studying the silkworm. During the early years of this century man continued the efforts to develop processes for manufacturing artificial yarns.

In recent years there has been successful commercial production of cellulose fibers which, although strong and durable, lack something in warmth, resilience, and ability to hold their shape.

With an abundant indigenous potential supply of protein in the United States it was but natural to seek a method whereby protein could be converted into a fiber, by-passing the animal and securing a product which would possess characteristics and properties as desirable as those of natural animal protein fibers. At the same time it appeared possible to do a more efficient manufacturing job than could the animal. It was known, for example, that in spite of thousands of years of breeding and developing a good strain of wool-producing animals, it still required two acres of land to support one sheep for one year and that the output of wool from this animal would not exceed 10 pounds. Whatever the virtues of the sheep as a wool producer it admittedly lacks manufacturing efficiency

From this knowledge it was reasoned that it should be possible to process protein, available in such abundance in the soybean and elsewhere, and make a fiber out of it. The sheep does it. Man ought to be able to do it.

In the telling, the process by which the humble soybean ultimately becomes a fiber is not particularly complex. Actually, however, years of study and experiment preceded the final development of the process. Like many other industrial processes which are basically simple, it didn't get that way without trial and error, study, research, and experiment. The twins, time and effort, played a vital role.

To begin with, the oil is extracted from the soybean through the use of a solvent. The residue is a soybean meal. The protein is removed from this meal by treating it with a weak alkaline solution, such as 0.1 percent sodium sulfite. The resulting solution is then clarified either by filtering or centrifuging. The protein in the curd is then precipitated by an acid and the resulting curd is washed and dried.

The clarifying of this solution is considered a chemical engineering accomplishment of unusual merit. The precipitation must be carried out at just the right temperature and pH in order to get a curd that can be handled properly during the subsequent washing and drying.

Once the protein is removed from the meal, it is dissolved to produce a viscous solution of about the same consistency as molasses. This solution must then be controlled very carefully It must have a high solids content, which is difficult to get because proteins in high concentrations tend to form a gel. Yet, with careful control, it is possible to produce solutions with as much as 20 percent protein.

The solution itself must then be aged at the correct temperature for an exact period of time before the required viscosity and stringiness are reached Moreover, it must be kept free of undissolved particles or air bubbles which would affect the spinning continuity.

The next process in the manufacture of soybean fiber is a rather conventional step in the general methods of making artificial fibers Here, fortunately, it was possible to take advantage of the experience of other industries to save what might possibly have been years of study and research The aged solution is forced through spinnerettes into an acid precipitating bath and the resulting filaments are collected from this bath on bobbins or reels. However, these filaments must be stretched as they are collected. This is done by pulling them through the acid bath and over two glass pulleys, one of which revolves faster than the other to exert the desired stretching effect.

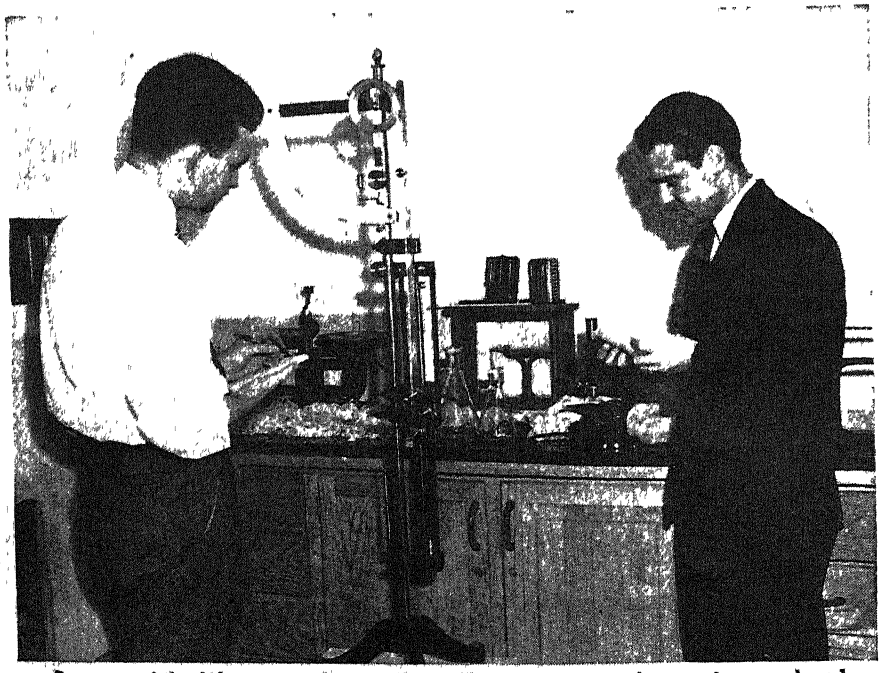
The fiber is then set by long immersion in a formaldehyde bath and is dried under controlled humidity and temperature, after which it is cut into desired lengths and is ready for shipment

CRITICAL CONTROLS—This is the process itself, in brief outline Not overly complex, it is none the less one which calls for exactitude, careful control, and constant checking all along the line. Let just one small phase of the operations get out of kilter and the entire process may well bog down.

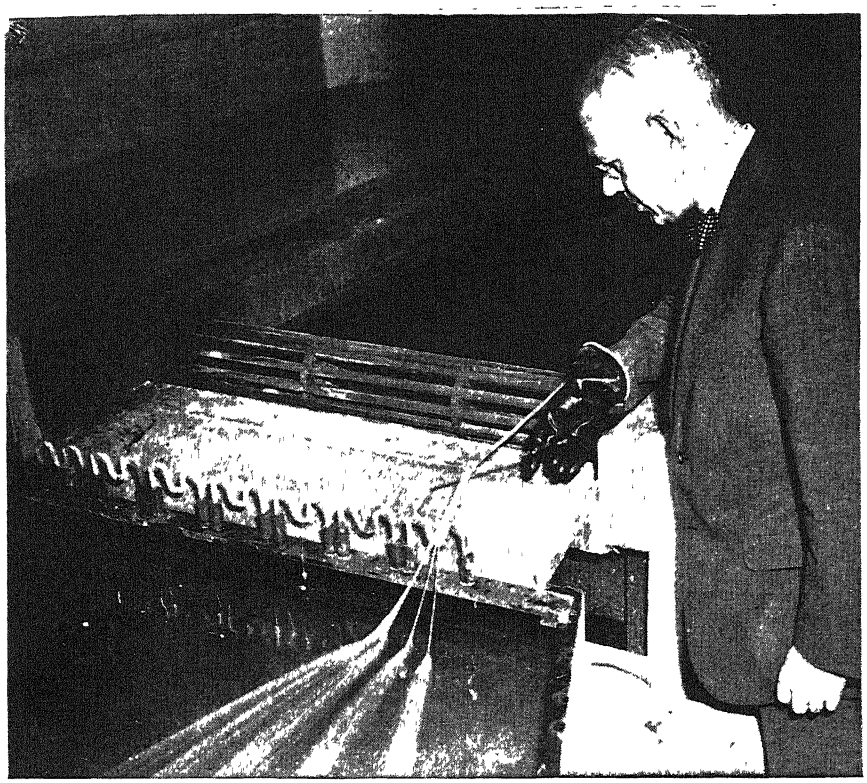
But the greatest single headache, if such it can be called, was not developing the process of making fiber out of soybean protein, so much as it was designing equipment and machinery to do this job on a production basis. It is one thing to make a product in the laboratory; quite another to make this same product on a large scale and on a basis of economy and efficiency which will permit it to be marketed competitively

However, designs for such machinery and equipment have been perfected to a point where a continuous manufacturing process is in commercial operation, with the protein solution being mixed in one part of the plant and the subsequent operations following in sequence until the fiber itself is cut and packed for shipment.

The current output of the fiber is small; it must remain so for a time yet. as allocation of raw materials, machinery, and equipment is such as to prevent securing additional manufacturing machinery and equipment. In the meantime, improvements are being made in equipment, machinery, processes, and product. Simultaneously,



A corner of the laboratory where soybean fibers are constantly tested as produced and where technologists conduct research in product and process improvement



Soybean fibers emerging from the spinnerettes are grouped first into three bands and then into one. Next processing step is a series of chemical treatments

small amounts of fiber are being supplied to various textile manufacturers to permit them to experiment with it and see just what can be accomplished in manufacturing it into finished textiles of many kinds.

MANY THINGS UNKNOWN—This fiber, it must be realized, is still a very new product. Admittedly, there are many things about it which are as yet unknown. Not yet can it be made, on a commercial basis, as strong as the sheep makes his fiber. Ultimately, there is every reason to believe that a soybean fiber can be made that is even stronger than wool. As more is learned about protein chemistry, still a most complex subject, many ways of improving the fiber will undoubtedly be found

Just what place soybean fiber will have in the textile world is still a question which time alone can answer It is obvious, however, that a non-animal protein fiber will be useful in making various textiles. The textile industry has proved itself capable of making good use of new man-made fibers in recent years. But to predict at this time just what the range of uses of soybean fiber is, how widely it will be used, or what it will cost, is to go into the realm of conjecture.

Indications are that the new fiber will find its price level at a point where it will compete satisfactorily with synthetic and natural fibers. Its cost is not expected to be an obstacle to its widespread use and acceptance.

Virtually all radically new industrial products, at some stage or other of their development, come up against the problems of applications and costs. Who, for example, would have been so rash a few years ago as to predict all the present uses of nylon? Or who today would venture a comprehensive prediction on the future uses of the new synthetic rubbers? Nor could today's rayon or nylon costs have been predicted when those products were almost brand new.

Right now it is possible to consider only the finished soybean-fiber product itself, recount accurately its present known virtues and drawbacks, and say that while its future seems to be assured there is no basis as yet on which to predict just how it will affect the textile world.

In any event, industrial America moves rapidly. It has a receptive mind. It looks with favor upon new products. It is eager to pioneer, to experiment, to develop. Doubtless the textile industry will take this new fiber, as it is doing today, and develop its uses. In such manner are new chapters written in the history of human progress

* * *

REFRIGERATORS

Will Improve, but Not Fantastically

THE FIRST refrigerators to reach the consumer when production is resumed will not be radical or revolutionary in design, it is predicted by W. Paul Jones, vice-president in charge of refrigeration for Philco Corporation.

"This prediction is based on the premise that manufacturers, distributors, and dealers will be anxious to get back into civilian business quickly," Mr. Jones says. "Immediate production and transportation of materials will offer plenty of problems in the early months after the war, even without the complications of radical design changes and tooling-up for new models At the same time costly experience in other industries has proved that the buying public reacts slowly and cautiously to radical design changes and a period of transition between the pre-war and real post-war models should be desirable from many angles.'

Indulging in the famous indoor sport of post-war speculation on the shape of products to come, many designers and pseudo-designers picture the post-war refrigerator as a fantastic piece of equipment, Mr. Jones points out. Some of these refrigerators have revolving shelves, or transparent cabinets, or a chute on the side for ice cubes. Some picture doors that open automatically with an electric eye, doors that raise, doors that drop, and many other dream features.

"Obviously a middle track is necessary to produce a practical piece of household equipment," Mr. Jones believes. "One thing is sure—there must be ample space for frozen food in the post-war refrigerator. The trend toward frozen foods is definitely here Of course the post-war refrigerator should have a humid area for the preservation of moist foods, cooked foods, and left-overs. The ideal post-war refrigerator would be one that limits regimentation to an absolute minimum; in other words, a refrigerator that doesn't force the housewife to put certain foods in certain places and into certain kinds of containers"

PENETRATING PRIMER

Assures Better Surface Finishes for Wood

A BETTER finish for home, school, and office furniture, much tougher than present practical varnishes or lacquers, is promised after the war through the use of a formulation which has been developed at the Du Pont laboratories for producing a base or prime coat. Its value lies in the extraordinary adhesion it provides for the top coat. The new so-called "penetrating primer," by affording improved "anchorage," permits the use of finishing lacquers which have extremely high scratch resistance. Such super-tough pyroxylin lacquers have long been available, but were impractical because a sufficiently strong adhesive bond with a wood surface could not be obtained.

"The big research problem in utilizing tougher furniture lacquers to resist wear, tear, and scratching," explains R. C. Peter, Du Pont Industrial Finishes Division development manager, "is a struggle between cohesion and adhesion. Visualize, for example, a table top to which has been glued sheets of paper and of metal. While it is impossible to strip off the paper, the metal can be removed with little difficulty, despite the fact that the strength of the glue is identical in both instances. The variable here is the difference in the cohesion of the two materials—that is, their ability to hold together.

"When the cohesion of a lacquer film

over a surface so exceeds the adhesion, it can be easily chipped from the underlying surface, as in the case of the metal sheets," said Mr. Peter. "The new first-coat material has a special elastomer, or rubber-like ingredient, that securely binds the top coat to the wood."

PORTABLE PIPELINES

Can be Laid Anywhere, Quickly Repaired

IF THERE IS any one pair of commodities that an army cannot do without for long, it is gasoline and oil. Moreover, it is equally important that these be available when and where they are needed in sufficient amounts. All of which means that sooner or later there had to be developed a faster, better method of transporting oil products under varying conditions. That method is today known as the front-line pipeline, invented by a Shell Oil Company technician

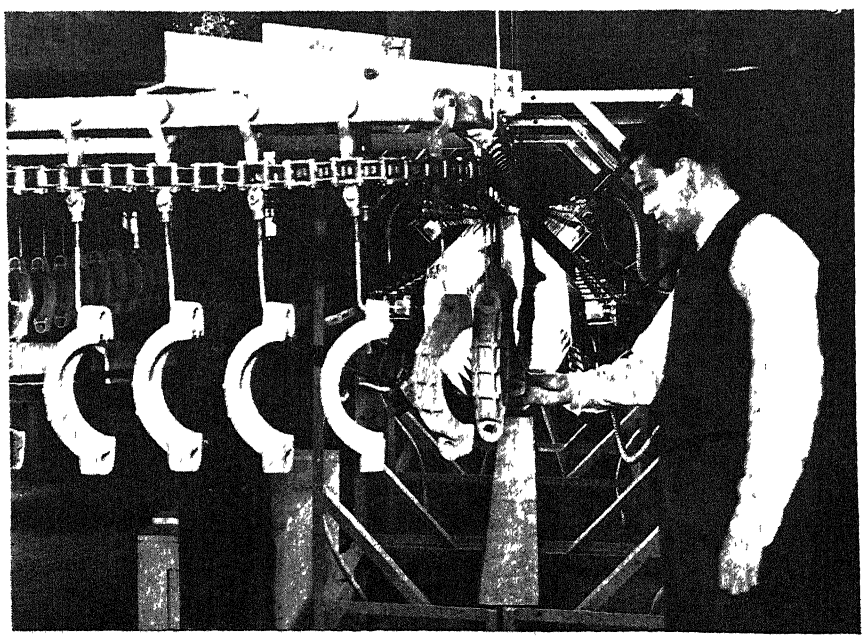
Briefly, a portable pipeline is made up of 20-foot sections of four-inch flexible steel pipe with pumping stations at 10-mile intervals. All the equipment is transported on trucks or trailers. In the field, the pipeline requires no trenches since it follows the contour of the terrain. In tests, it has been wrapped around trees, bent over hills, and curved across streams without decrease in efficiency.

Perhaps the outstanding advantages of the front-line pipeline is the speed with which it can be restored to normal service after damage by the enemy. Pumping stations are operated by gasoline-fueled engines. If put out of action, a station can be repaired in a few hours. Meanwhile, the system's capacity is reduced only 30 percent. In fact, two adjacent pumps can be damaged and the system will continue to operate.

The pipe itself is a poor target for enemy bombs. However, once a break does occur, repair crews quickly locate it, shut down valves and swing in a replacement piece of pipe, all within one to four hours! This speed is due in large measure to a simplified yet effective coupling designed for use on grooved-end pipe It is composed of only two malleable iron castings, two bolts and nuts, and a synthetic gasket, and assures a tight seal even during movement of the pipe ends. One type, produced by the Gustin-Bacon Manufacturing Company, allows a deflection of three degrees. No special tools are required to fit the coupling—an ordinary open-end or socket wrench suffices.

Continuous exposure to the elements and contact with soil subject the couplings to many corrosive influences that might impair its operating efficiency. Consequently, it is essential that the couplings be finished so as to prevent rust and scale formation. In the finishing room of the Lake City Malleable Company, one of the larger producers of the coupling, it is the practice to finish each coupling with a coat of Sherwin-Williams infra-red reflectant, olive-drab paint. Because of the high output of the foundry, the finishing room would find it extremely difficult to maintain a fast pace were it not for an extremely efficient finishing production line.

After each casting has been dressed down, it is suspended on a hook from a monorail conveyor. It then travels to a tank containing the olive-drab paint where it dips down for a quick immersion. As the couplings come out of the paint tank and move along the conveyor, a guide tilts them to allow surplus paint to drip off. When the couplings pass this guide, they straighten out and enter the first of two infra-red ovens where the finish is dried.

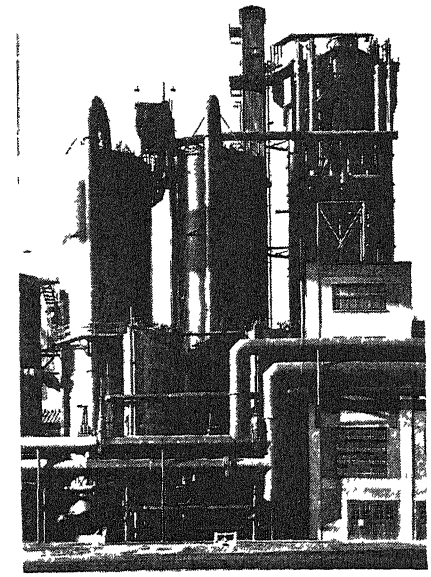


Couplings for portable pipelines emerging from an infra-red drying oven

SULFUR RECOVERY

Also Eliminates Hydrogen Sulfide Troubles

PURIFICATION of coke-oven gas to protect vital manufacturing equipment has been started by the Ford Motor Company, and in the same operation another product—sulfur—is added to a long list of those already extracted in coal coke-gas processing.



Ford's gas-purification equipment

The Ford sulfur plant is now in operation, extracting approximately six tons of 99-percent pure sulfur daily. More than a year was required for construction of the plant.

The new equipment, built by the Koppers Company, extracts sulfur by the ammonia thylox method Despite the fact that it is one of the largest of its kind in the world, two skilled men can operate the plant at peak production.

Due to its destructive corrosive qualities, hydrogen sulfide in coke-oven gas has long been a source of trouble to industry. By removing the objectionable sulfur and thus prolonging the life of millions of dollars worth of equipment, the new plant, despite its cost, will, it is estimated, be self-liquidated in three years. The sulfur itself, although valuable as a base for fungicides or for bleaching wood pulp, constitutes only a fraction of the real saving.

Actual operation of the new plant is simple. Ammonia and coal tar have already been removed from the gas by the time it reaches the sulfur plant There it is piped into cylindrical tanks where it is cooled. Then it goes through a series of treatments with thylox and ammonia, in the last stage of which the sulfur is converted into a solid which is melted and poured into iron molds, allowed to solidify, and then stacked into piles for shipment.

WOUND INFECTION

Prevented by Use of Layer of Cellophane

A WRAPPING of moisture-proof cellophane, acting as a barrier against germs which might infect the wound from the outside, is a feature of an improved pressure-dressing treatment for burns and other wounds.

The technique, which is being employed by Dr. Neal Owens, professor of plastic surgery at Tulane University Medical School, is described in a recent

Zenith's Crusade to Lower the Cost of Hearing
Brings High Quality within Reach of All!

The New Zenith Radionic Hearing Aid

Another Zenith "First"!

DAILY, all over America, hard of hearing persons who had given up hope of being helped, or who could not afford an adequate hearing aid, are finding a new world of happiness They are discovering the thrill of "Radionic Hearing" with this high quality precision instrument at about one-quarter the price of other vacuum-tube instruments on the market today!

Zenith, pioneer in radionics and world's leading manufacturer of radionic products exclusively, has brought the hard of hearing "Another Zenith First" It places the fine precision quality that modern science and engineering can produce within reach of *all* who need it

If we at Zenith never made a dollar on the New Zenith Radionic Hearing Aid, we would feel repaid a thousandfold by the expressions of delight, the smiles and in many cases the tears, of sheer gladness on the faces of these grateful people.

For the first time, many of them are able to hold vital wartime jobs and do their rightful share in Uncle Sam's wartime emergency. Many are hearing, *for the first time in years,* the voices of their children, their families, their friends. Handicapped youngsters, too, can now be saved from lives of failure and misunderstanding due to hearing deficiencies. 78% of all who are buying this revolutionary new instrument have never owned an adequate hearing aid before!

If you are hard of hearing, you owe it to yourself—your friends—and your country—to see a demonstration of the great advantages which ONLY ZENITH offers in a hearing aid. If you have a relative or friend who is hard of hearing, *you owe it to them* to urge attending a demonstration now going on at your local optical establishment franchised by Zenith. Let *their* ears be the judge. No one is pressed to buy. No salesman calls at the home For free descriptive booklet, mail the convenient coupon below—today.

*

To Physicians: A detailed scientific description will be sent upon request. Further technical details will appear in medical journals.

$40 READY TO WEAR

Complete with Radionic Tubes, Crystal Microphone, Magnetic Earphone and Batteries. One *model*—no "decoys"... One *price*—$40... One *quality*—our best. Covered by a liberal guarantee.

Accepted by American Medical Association Council on Physical Therapy

ONLY ZENITH GIVES YOU:

1 The fine precision quality that modern knowledge and engineering make possible in a hearing aid, yet priced at only $40, complete, ready to wear *One model*—no "decoys".. *One price*—$40 . *One qualsty*—our best You need not pay more or accept less.

2 Four-Position Tone Control. The flick of your finger instantly adjusts it to the most effective combination of low, medium and high tones for individual needs in varying surroundings, hearing deficiencies in various ranges No further adjustments necessary.

3 Special Battery-Saver Circuit Insures economy in battery consumption . . . results in substantial saving of battery life and battery replacement expense

4 Zenith Quality—Zenith Guarantee. Zenith, world's leading manufacturer of radionic products exclusively, is fortunate in having the knowledge of precision production that makes possible this quality hearing aid at a remarkably low price Guaranteed for a full year, with unique service insurance plan

The Zenith Radionic Hearing Aid is available through reputable optical establishments franchised by Zenith

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RADIONIC PRODUCTS EXCLUSIVELY—WORLD'S LEADING MANUFACTURER

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There are cases in which deficient hearing is caused by a progressive disease and any hearing aid may do harm by giving a false sense of security. Therefore, we recommend that you consult your otologist or ear doctor to make sure that your hearing deficiency is the type that can be benefited by the use of a hearing aid.

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Please send me your FREE descriptive booklet on the New Zenith Radionic Hearing Aid.

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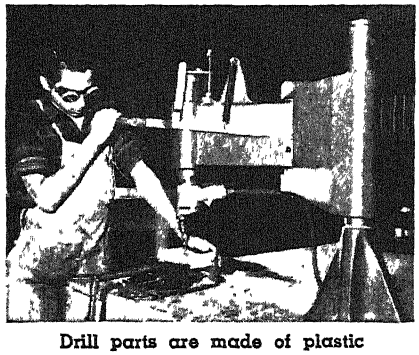
issue of *Surgical Clinics of North America.*

Dr. Owens has been perfecting the pressure method for the past ten years and has used it on several hundred cases. Before adopting the cellophane feature he had noted that even surgical wounds, such as those made during removal of healthy skin for grafting, occasionally became infected through the entire thickness of the dressing. He therefore conducted laboratory experiments which proved that germs could be drawn, by capillary attraction, through as many as 64 thicknesses of gauze. However, when a layer of a special type of moisture-proof cellophane was interposed the germs could not get through.

PLASTICS IN TOOLS

Light Weight and High Strength are Features

AN EXAMPLE of the use of casting resins in industrial equipment is found in the successful use of "Toolite" for structural parts of radial drills at Consolidated Vultee Aircraft Corporation.



Drill parts are made of plastic

Toolite, produced by Adhere, Inc., is now being used for a wide variety of production tools.

Light in weight, tough, inexpensive, and having six to seven times the compressive strength of similar materials, the ultimate possibilities of this thermosetting cast resin are only beginning to be foreseen, according to aircraft manufacturers. Toolite is lighter than magnesium, yet does not break nor damage easily and has compressive strength up to 20,000 pounds per square inch. It is inert to ordinary cutting compounds, passes oil and water absorption tests, and withstands a temperature of 400 degrees, Fahrenheit.

AIR-COOLED ENGINES

Increased in Power by Aluminum Bonding Process

A PRACTICAL method of accomplishing the hitherto impossible task of welding—or, more accurately, of chemically bonding—pure aluminum to steel has been used in the production of Ranger 12-cylinder engines for more than a year. Known as the Al-Fin process, announcement of its development has been withheld until the present for reasons of national security.

Through its application in the construction of cylinder barrels for Ranger 12s, power output of these inverted in-line air-cooled engines has been increased to the point where today they produce more horsepower per pound of weight than any comparable aircraft engine.

Up to now, two methods chiefly have been employed to assist in dissipating heat from air-cooled engine cylinders One was to machine suitable cooling fins right out of the steel cylinder stock; the other, to shrink-fit around the steel barrel an aluminum alloy sleeve with integral cooling fins. This necessarily had to be an aluminum alloy, which has lower heat conductivity than pure aluminum, because the pure metal is too soft for a shrink fit. This method presents problems of inefficient heat transfer at the line of shrink between the steel and the aluminum.

It was to overcome this problem that the Al-Fin process was developed. When an aluminum muff is shrunk on a steel barrel, the contact between the two is mechanical and, hence, is imperfect. For one thing, steel has a rate of expansion different from aluminum alloy. Moreover, no matter how well machined are the mating surfaces, appreciable variations in the degree of mechanical contact of the two cylindrical surfaces result in minute patterns of greater and lesser heat transference. In fact, theoretically, the mechanical efficiency of the joint can never exceed 50 percent.

The bond formed between the steel and the pure aluminum by the Al-Fin process is 100 percent, since it is a chemical composition at that point. The composition of the bond forms a perfect bridge for the transmission of heat from the steel barrel to the pure aluminum cooling fins.

The bond also renders ineffective the difference in expansion characteristics of the two metals. Broadly speaking, the process makes the ductile aluminum expand and contract along with the more rigid steel and supplements the steel with the heat dissipating qualities inherent in the lighter metal. The result is a barrel with the lightness and heat transferring ability of pure aluminum plus the strength of steel.

Essentially, the Al-Fin process is a means of permanently bonding aluminum and steel into an integral whole. It may offer advantages in innumerable applications where highly efficient heat transmission with savings in weight is desirable. The automotive and air-conditioning industries are finding much of interest in the process. It may also prove useful in structural applications where thermal problems are not involved.

INSULATION TESTS

Conducted in Clouds and Snow-Storms Formed in a Bottle

POCKET-SIZED clouds and snowstorms that would fit into your hat are helping speed the development of more powerful electrical systems for American warplanes. Confined in a glass flask not much bigger than a milk bottle, the clouds and the snowflakes that flutter down from them are "manufactured" by Dr. Leo J. Berberich, of the Westinghouse Research Laboratories, to test the effectiveness of insulation for aircraft power systems.

With this "bottled weather," Dr. Berberich determined how climatic conditions and air pressures at altitudes up to 12 miles—65,000 feet—affect air gaps between uninsulated parts of a plane's electrical system, such as terminals, carbon-brush holders for aircraft generators, and the contacts of switches.

"A thick cloud can be created in a few seconds by pouring liquid air into warm water," he explains. "When the intensely cold—310 degrees below zero, Fahrenheit—liquid air comes into contact with the water, the liquid air evaporates so rapidly that it 'kidnaps' minute droplets of the water and carries them off into the air, forming a dense cloud.

"Then the cloud is ushered into the glass test chamber through a tube. When the test chamber is cooled below the freezing point, snow crystals form in the tiny cloud and drop onto the insulation-testing apparatus in the bottom of the flask."

To test different types of insulation in the weather bottle, Dr. Berberich fastened two half-inch squares of brass sheet to a larger slice of the insulating material. Between the brass squares he left a fraction-of-an-inch space and to each brass square he attached a wire carrying an electric current.

Then the test piece was placed in the flask and the flask closed with the wires coming out through air-tight seals.

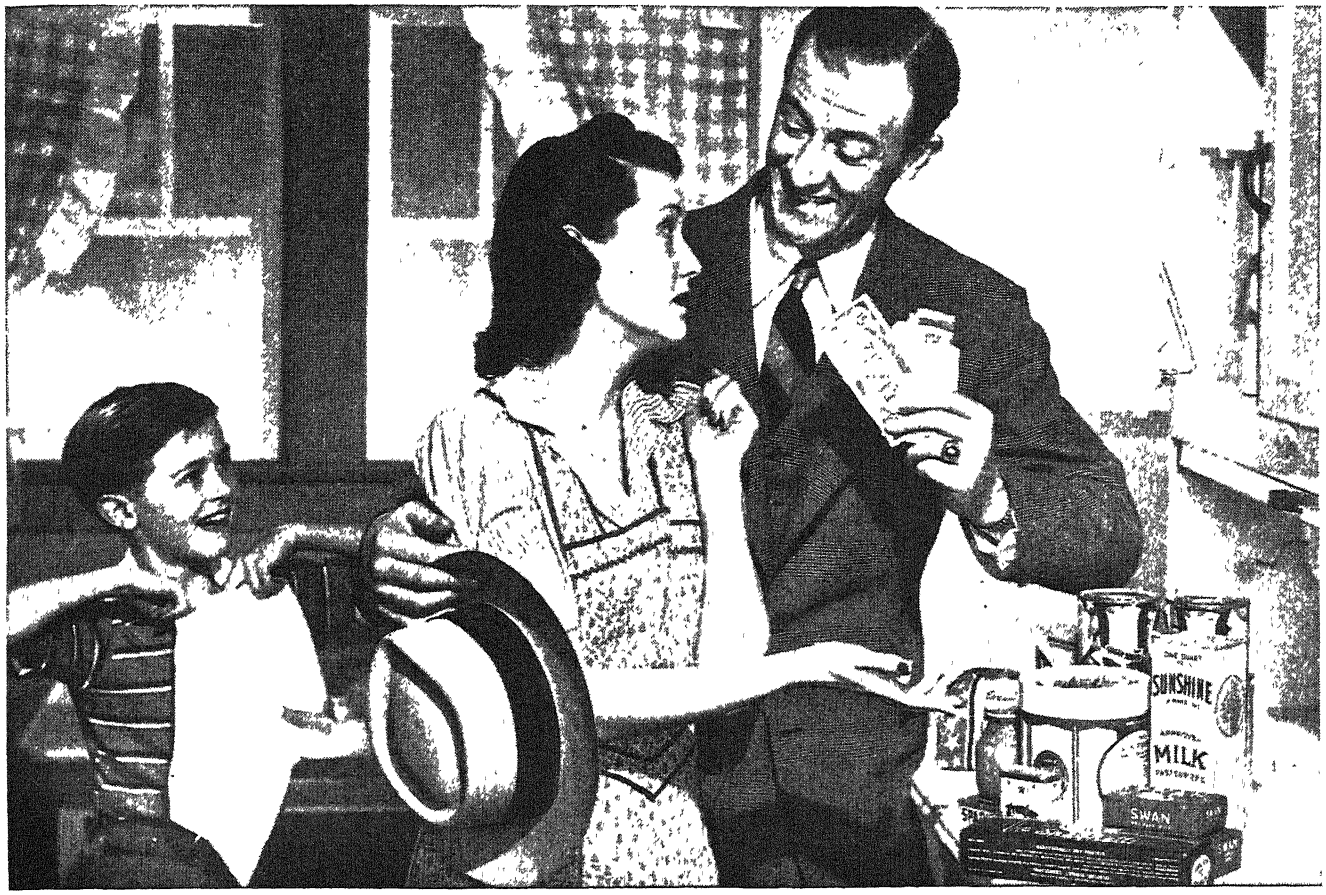
"Pumping air out of the sealed flask simulated the low air pressures found at high altitudes," he says, "and the sub-zero temperatures of the stratosphere were duplicated by surrounding the flask with a mixture of dry ice and alcohol.

"At various 'altitudes' and temperatures, with dry air in the flask and then with clouds or snow, each specimen was tested. Voltmeters connected to the wiring circuit within the flask measured the 'pressure' at which the electricity sparked over the insulation from one piece of brass to the other."

Air gaps between uninsulated parts were tested by placing two small brass rods in the flask so that their tips were a small distance apart.

To an ever-increasing degree, Dr.

Bottled clouds for insulation tests



What good is a $10.00 raise ...if it then costs you $12.00 more to live?

SURE WE ALL want a raise . . . but raises today are bad medicine. Bad medicine for you. Bad medicine for everybody else. And here's why . . .

Suppose you do get a raise . . . and a lot of others get one, too. What happens? The cost of manufacturing goes up. Naturally your boss has to add this increase in cost to the price he asks the retailer. And the retailer, in turn, raises his price to the consumer . . . that's YOU.

Multiply these hundreds of items that everybody has to *pay more for* by the thousands of other workers who want raises . . . and by the thousands of business men and farmers who want more money for their products . . . result . . . you and all the others need another raise to make ends meet.

And so it goes . . . wages and prices chase each other up and up . . . until prices get so high that your dollar isn't worth a dollar any more.

So what good is a raise if your living costs go up even faster? And there's so little you can buy today anyway . . . with most factories in war production.

Of course it's hard to give up the luxuries of life . . . and even harder to give up some of the necessities. But this is War! And when you think of the sacrifices our fighting men are making . . . many of them giving up their lives for us . . . no sacrifice we can make should be too great.

So if you want to be able to enjoy the good things of life in the peaceful days to come . . . if you want to speed victory and thus save the lives of thousands of fighting men . . . start doing these seven things now . . .

1. Buy only what you *need*. Take care of what you have. Avoid waste.

2. Don't try to profit from the war. Don't ask more than you absolutely *must* for what you have to sell . . . whether it's *goods* or your own *labor* you're selling.

3. Pay no more than ceiling prices. Buy rationed goods only by exchanging stamps. Otherwise, you're helping the black-market criminals, hurting yourself and all other good Americans.

4. Pay taxes willingly. They're the cheapest way of paying for the war.

5. Pay off your old debts—all of them. Don't make new ones.

6. If you haven't a savings account, start one. If you have an account, put money in it—regularly. Put money in life insurance, too.

7. Buy and hold War Bonds. Don't stop at 10%. Remember—Hitler stops at nothing!

Use it up . . . Wear it out. Make it do...Or do without.

HELP US KEEP PRICES DOWN

A United States War message prepared by the War Advertising Council; approved by the Office of War Information, and contributed by the Magazine Publishers of America

Pick-up coil for the railroad 'phone system is shown above, in box projecting toward rail. At right is shown hand-set in engine cab, with signal loudspeaker at upper right

Berberich explains, large planes depend upon electric power—the electrical load on big military planes has increased 10 times in the last decade. "It would be simple to 'over-insulate' a plane for safety," he says, "but aircraft designers fight to trim off every unnecessary ounce of material and to reduce the size of every single piece of equipment so their plane will fly higher and faster with a bigger bomb-load. That's the purpose of these tests—to determine safe minimums for insulation and the smallest safe air gaps between uninsulated parts of the electrical apparatus aboard a plane."

ARC WELDER

Has Wide Current Range and Dual Control

RATED AT 200 amperes, and light in weight, a new "Shield-Arc" engine-driven welder is rugged of construction, with powerful enclosed rubber mounted engine of 29 horsepower. This new unit, supplied complete with base and canopy, has a current range of 40 to 250 amperes. Dual control of welding current is accomplished by adjustment of series fields and generator speed.

Designed for metallic arc welding, with bare or coated electrodes, this new Lincoln model also supplies uniform welding current for carbon-arc welding.

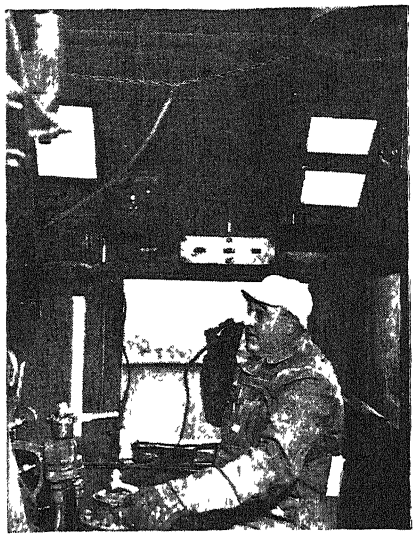
RAILROAD 'PHONE

Permits Communication by Means of Carrier Currents

ESTABLISHMENT in practical operation of a two-way electronic train telephone system, permitting continuous voice communication with moving trains, between trains, and between the head and rear of trains, was announced recently by the Pennsylvania Railroad.

The initial installation has been made on the 67-mile Belvidere-Delaware branch, running northward from Trenton, New Jersey. Officials state that, while not yet adapted to general use, the new means of communication has now definitely demonstrated its capability of adding materially to the efficiency of controlling train movements. It has been produced in collaboration with the Union Switch and Signal Company, following several years of intensive experimentation and development which are still continuing.

This system, the only one of its kind so far established, has been applied to the freight service on the branch, which is of substantial volume It permits the



crews of freight trains and block operators in wayside towers to talk to one another at any time for the transmission of orders, reports, and information on matters affecting train operation. The conductor in the cabin car and the engineman in the locomotive cab may also talk to each other at will, and the crew of one train may communicate with the crew of another several miles distant.

The equipment required for the new communication system has been installed on 10 locomotives and 10 cabin cars, and in a block station at Frenchtown, New Jersey, 30 miles north of Trenton. Installation is also under way at another block station in Trenton, where the branch leaves the New York-Washington main line.

The new system utilizes electrical principles employed in both radio and the wire telephone and combines the best practical advantages of both. It gives all the flexibility and ease of communication between trains and wayside stations, between the ends of trains, and from one train to another, that would be possible with radio. At the same time, by utilizing transmission paths provided for its own special purpose and confined to railroad property, instead of the universal paths of nature over which radio waves travel, it obviates the necessity of appropriating radio wavelengths from the limited range available to the crowded and competitive sphere of radio communication.

In addition, it provides a solution for certain practical difficulties which were encountered in adapting pure radio to railroad use, and leaves the air to those forms of transport which have no physical ground contacts and to which radio has been found to be ideally adapted Commenting upon the results thus far observed, railroad officials, while emphasizing that the new system is still in the development stage, express the opinion that, when further perfected, its extension to other parts of the railroad will probably be found desirable

The new system utilizes high frequency alternating currents transmitted along the rails, and also along wires on poles parallel to the track. These are termed "carrier" currents and have impressed upon them the impulses of the telephone currents which are produced by talking into the telephone instruments. By means of apparatus attached to the locomotives and cabin cars, these telephone currents are received into and sent out from the trains and the electrical impulses are transformed back into sound by the telephone instruments at the receiving end, whether on a train or in a wayside tower.

COLOR CODE

Devised to Standardize Safety Practices in Industry

COLOR today is widely utilized in industry to promote safety. But because it has been used inconsistently and often promiscuously, to the point of confusion, a standard safety color code has been worked out for industry that should do much to improve this important phase of the science of functional color.

The color code is primarily a recommendation to industry to regularize the identification of plant safety equipment and hazards by specific colors and color symbols. The Du Pont Company Finishes Division, in developing the code, has respected traditional associations of color (such as red with fire protection, green for safety) while applying basic knowledge of color psychology and hue visibility

If color is to contribute its maximum effect upon industrial safety, the proposal states, it must do more than merely attract eye attention. Simple logic and scientific knowledge should combine with standardization of practice in color identification procedure.

The color code avoids what it describes as common errors in current color safety practice Probably the most frequent malpractice is overdoing color by including so many haphazard "wolf cries" that the system defeats itself by failing to impress the worker, if not by actually distracting his attention. Also, if a certain hue is used to point-up a hazard it should not be used to call attention to protection equipment. A given color should mean a given thing, or logical classification of things, so that the employee will associate that color with one precise safety message, anywhere throughout industry.

Six basic color standards are recommended in the new code· yellow, orange, green, red, blue, white (black or gray). The meaning of each color can be given added significance by employing it, when reasonable, in symbolic shapes, such as alternate black and yellow bars; an orange diamond; a green

cross, a red square, a blue circle, a white (gray or black) star.

Yellow, being of highest visibility in the spectrum, is recommended for use in conjunction with black striping to mark "strike-against," stumbling, or falling hazards.

Orange, psychologically the most stimulating and aggressive of all hues, is chosen to command attention to machine hazards such as in cutting, forming, and stamping operations. A triangle (or arrow) in "Alert Orange" may indicate the critical point of the hazard.

The traditional color and symbol of safety is a green cross. Hence, the code designates it for use over doorways to first-aid rooms, to mark locations of first-aid kits, stretchers, gas masks, respirators, and other safety equipment.

Because red has long been applied to fire protection apparatus, it should remain as standard in this respect—exclusively. The practice of identifying danger with red is discouraged. (Scientifically, red is poor, being low in visibility). Red squares on walls or bands on pillars indicate the location of extinguishers, hose connections, exits, and so on. Red squares on the floor beneath such apparatus, as well as in front of fire doors, tend to discourage obstruction with litter, cartons, and waste receptacles.

Borrowing from the railroad industry, the code sets a solid blue circle as a symbol of caution against starting, moving, or handling any machine, device, or equipment. The "Precaution Blue" sign should be hung on control valves and equipment condemned or undergoing repair.

The sixth standard includes the neutral colors—white, gray, black. These are for simple traffic direction and good housekeeping Aisle marks and storage spaces are designated by white lines on dark floors, or black on light floors. Gray is practical for waste receptacles, cuspidors, rubbish boxes, and the like, and where management is insistent upon extreme neatness a white star may be conspicuously placed on containers or on the wall above container locations, or painted in an area on floors beneath receptacles.

In sum, the color code for industry is designed to (a) employ few colors, each distinct and readily recognized, (b) establish specific and uniform meanings for each color, (c) provide ready identification of hazards or conditions to aid in employee safety, (d) reduce to a minimum the effort required to learn and retain color meanings, (e) readily identify and locate fire protection and safety equipment, and (f) encourage good housekeeping.

TANTALITE

Plays Vital Role in United Nations War Effort

DEEP in the barren interior of northeastern Brazil, Americans and Brazilians are waging a hide-and-seek battle with nature to find and mine tantalite, the new black gold of the United Nation's war effort. This rare pitch-black mineral ranks as one of the most important resources in the whole Allied war chest; tantalum, the metal derived from tantalite, gives added power and range to United States and United Nations war weapons.

While tantalite's exact military uses are still military secrets, an idea of the heavy wartime demand for the mineral can be gleaned from its air priority. Of all the strategic materials sent by air to the United States from Brazil and other nations, tantalite alone holds the top rating: A-1-A.

Producing 52 percent of the world's highest-grade tantalite here is far from easy, as Brazilians and Americans toiling in the torrid sun of Brazil's bleak "sertao" (interior) have found out. Biggest problem of all is locating the black substance in this huge, mountainous area, stretching in a wide arc of 3600 square miles through the states of Paraiba and Rio Grande de Norte.

Mining men compare the tantalite operation to the proverbial "looking for a needle in a haystack"—and it isn't hard to see why. Tantalite ore usually is found clustered with other minerals in towering, odd-shaped rock formations called pegmatite dikes. Or it may be found in alluvial deposits beneath the level valley land. But the problem comes in determining which of the thousands of dikes and deposits in the region contain sufficient tantalite to warrant a big, costly mining effort.

Possibly the most amazing thing

now wear "Plastic Overcoats"

Bausch & Lomb 7X, 50mm Binocular

Denied the continued use of vulcanized rubber for binocular covering, the U. S. Navy sought a plastic material that would furnish the metal-clinging, watertight, sure-grip properties required in sea-duty binocular body covers.

Because the cooperative effort of engineers representing Bausch & Lomb, the plastics manufacturer and the Navy solved the difficult details posed by this problem, the new all-weather Vinylite coat on today's binoculars is as good as and, in some important respects, better than the former rubber coats. This plastic does not deteriorate in sunlight and clings more firmly to the metal body.

This superior covering material will be on the *better* Bausch & Lomb Binocular that will be available after Victory, one more reason why Bausch & Lomb Binoculars will still be known as "the world's best—by any test."

BAUSCH & LOMB
OPTICAL CO. ROCHESTER, N. Y.
ESTABLISHED 1853

Makers of Optical Glass and a Complete Line of Optical Instruments for Military Use, Education, Research, Industry and Eyesight Correction and Conservation

Washing-up a plastic printing plate

about tantalite is the small, though priceless, amount of product resulting from an incredible amount of work. As one operater puts it: "We're pouring out gallons to get a drop." Here are some figures which point out the complexity of the tantalite business:

An estimated 3000 tons of rock must be mined to get one ton of tantalite, and it takes one man 130 days to crush, wash, and prepare a ton of the ore for shipment. This becomes even more remarkable when it is realized that tantalite mining, despite the recent arrival of American mechanical equipment, is still basically a hand-picking and hand-washing operation.

PRINTING PLATES

Made of Plastic and Paper, Used in Photo-Lithography

Out of experiments which began nine years before the war, has come an invention which today is serving many governmental agencies and may tomorrow revolutionize the mechanics of offset printing throughout the world. This invention is a flexible printing plate made of paper and Plaskon resin glue.

Paper sheets are permanently bonded together with waterproof Plaskon urea-formaldehyde resin and their outside surfaces are coated with this same material. The printing side is then coated with three layers of a special alcohol and clay emulsion and the plate is ready for the engraving process. Such plates can be manufactured with existing machinery in practically any paper mill.

Experts of the offset printing industry who have tested the new plastic plate state that it not only restores certain advantages lost when metal replaced stone as a printing base, but also adds new advantages. With copper and other standard plate materials growing more scarce because of the war, the non-metal plate is looked upon as a "life-saver" by the nation's 4000 lithographers, who are hoping it will soon be released for their use.

Costing far less to begin with, the plastic plate will bring users savings in shipping costs, since each weighs but a fraction of a comparable copper plate. The non-metal plates will require less storage space after being used and, unlike metal plates, will not have to be protected against damage from air or water, since they are impervious to both.

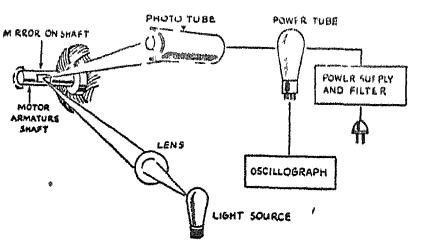
The plastic plates are used in offset printing in the same manner as metal plates. Once the plate is sensitized with a solution of albumen bichromate of ammonia, the subject to be printed is placed on it and it is inserted in a vacuum frame. On exposure to light from a carbon arc lamp, the image is transferred to the plate's alcohol-resin surface. This exposed surface is then coated with developing ink, washed until the print becomes clear, and etched with a chemical solution. When the plate is clamped to a cylinder of an offset press the image is first imprinted on a rotating rubber blanket and then transferred to paper.

Inventors of the new plastic-paper printing plate are William C. Toland and Ellis Bassist of the Plastolith Company.

MECHANICAL MATHEMATICIAN

Aids in Study of Motor Deceleration

That mechanical mathematician, the phototube, went to work on another job recently when H. C. Anderson of the General Electric Company used the phototube in a set-up designed to count



Set-up for motor-deceleration study

the number of revolutions a motor armature makes after the electricity has been cut off and a brake applied to the motor.

A tiny mirror no bigger than a baby's fingernail is glued to the shaft of the motor so that it reflects a beam of light every time the armature completes one revolution. This beam of light enters the phototube which, in turn, is connected to an oscillograph galvanometer. The deflections of the galvanometer are recorded on a photographic film and, at the same time, a visual record of the current is photographed.

Thus it is possible, by examining the oscillograph's film, to count the number of revolutions the armature makes after the current has been cut off and until the motor armature comes to a complete stop.

FLAVOR AND VITAMINS

Both Essential To Success of Dried-Food Industry

Dehydration is a relatively new industry with new technical problems, and the preservation of food by this process after the war will depend to a large extent on the success of research workers in developing methods which will insure palatable and nutritious dried vegetables. So says Dr. J. C. Moyer, chemist at the New York State Agricultural Experiment Station at Geneva. Doctor Moyer and his associates have been studying the effects of dehydration, and of the steps in preparing vegetables for drying, upon the flavor and vitamin content of the finished product.

"Much progress has been made in the past three years, and most dehydrated vegetables today have at least 90 percent of their original carotene, or vitamin A, and 80 percent or more of their thiamin, or vitamin B1," he says. "The destruction of ascorbic acid, or vitamin C, however, frequently amounts to one half to two thirds of the original amount."

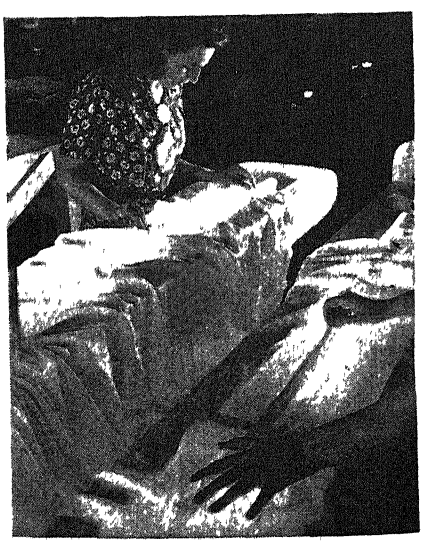
One of the most important factors affecting the flavor and nutritive value of dehydrated vegetables is the method of blanching the fresh vegetables, says this authority. Blanching is necessary to destroy or inactivate the enzymes which would otherwise impair the flavor of the dehydrated vegetables and would also greatly reduce their vitamin content. On the whole, blanching with boiling water was found to be more efficient than blanching with steam in the Station experiments, although with certain vegetables and in large-scale operations steam blanching may be more practicable. The drying process itself causes little loss of vitamin A and vitamin B1, but vitamin C is readily destroyed at this step in the operation, depending upon the kind of vegetable.

INSPECTION TABLES

For Parachute Manufacturers, Would be Useful Elsewhere

Illuminated tables designed especially for parachute inspection have now become fixtures in plants producing escape and aerial delivery parachutes for the armed services.

Designed and perfected by the Reliance Manufacturing Company, the tables are 14 feet long and have glass-paneled top surfaces, 8 inches wide and 12 feet in length. Lighted from below



Illuminated tables speed inspection

with three 30-inch blue-white fluorescent tubes, the tables now are government-required equipment for all parachute manufacturers.

The lighted panel facilitates the careful examinations of parachute stitching. If one of the estimated 250,000 stitches fails to catch the edge of the material, it is quickly detected by the inspector and the entire section of the canopy is rejected. Similar types of tables could be used to speed up inspection and assembly jobs in other industries

MOTOR SPEEDS

Recorded Automatically in Wind Tunnel Tests

ELECTRONIC robots that read instruments far more accurately than a man can, and which automatically print their readings on a strip of paper, are used to measure with high precision the speed of motors used in airplane wind-tunnel tests, according to Everett S. Lee, engineer in charge of the General Engineering Laboratory of the General Electric Company.

Models of newly designed airplanes, being tested in wind tunnels, are powered with small electric motors, corresponding to the gasoline engines of full-sized planes. In order that information about the performance of these motors may be extended accurately to the big airplanes, data about their operation must be determined with great precision

The indications picked up by electronic tubes, Mr. Lee explains, cause the rotation of a tiny thyratron motor, which in turn drives wheels carrying type numbers. When the operator wants to take a reading he presses a button, and the type wheels print their setting at that moment.

ROT-PROOFING

Research With Copper Soaps Gives Promising Results

COPPER soaps are employed as rot-proofing agents in intensified methods developed to prevent rotting and mildewing of fabrics, particularly under conditions of military service, according to a report to the American Chemical Society. That copper naphthenate leads other copper soaps in efficiency in the battle against rot is indicated by research conducted by Paul B. Marsh, Glenn A. Greathouse. Katharina Bollenbacher, and Mary L. Butler of the U. S. Department of Agriculture.

"From the standpoint of rotting, one of the most severe conditions to which a fabric may be exposed is contact with moist soil," the report declares. "Sandbags are often placed in direct contact with the ground and may contain soil as well as other filling materials. Many other mildew-coated fabrics may be expected to come in contact with soil for longer or shorter periods during storage or use.

"Cotton duck strips treated with copper naphthenate, copper oleate, copper tallate, and copper hydrogenated resinate were placed in moist soils at 85 degrees, Fahrenheit, and the strengths of the fabrics at the end of a nine-day period were recorded. Under the conditions of this experiment, copper naphthenate provided effective protection at lower copper concentrations on the fabric than did any of the other three copper soaps.

"Similar burial tests were made in soil with fabric treated with copper naphthenates made from naphthenic acids from different original sources. Fabric treated with a copper naphthenate made from a naphthenic acid of West Coast origin retained the following percentages of the original strength after the burial test in four different soils: 36, 76, 83, and 85 percent.

"Fabric treated with copper napthenate made from naphthenic acid of Mexican origin retained 19, 76, 85, and 94 percent of the original strengths for the same copper concentrations on the fabric; fabric similarly treated with copper naphthenate made from a naphthenic acid of South American origin retained 40, 71, 85, and 86 percent of the original strength. Since this superiority of copper naphthenate was so clear-cut and could be demonstrated repeatedly in the soil burial test, experiments were devised to determine its cause.

"Investigating further into the fungicidal capacity of copper naphthenate, it was found that the material had good protective power against growth of the copper-tolerant fungus, 'aspergillus niger.'

"The tests indicated that the superiority of copper naphthenate over other

Ingenious New Technical Methods

Presented in the hope that they will prove interesting and useful to you.

Center Scope Brings Optical Precision to Machine Shop Operations

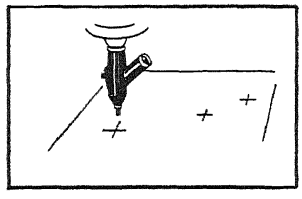
The Center Scope is an optical centering and locating tool that can be easily and quickly used on any machine to center work reference lines to a spindle axis. It permits accuracy to a degree never before obtainable, as the optical beam or line of sight is absolutely inflexible and cannot be distorted.

The Center Scope's easy accuracy eliminates many human errors, as the operator can see just what the cutting tool will do before it is actually fed into the work. It increases production, improves efficiency and prevents spoilage. There is no pressure on the work piece nor is it subject to wear or changes in temperature—for the Center Scope never touches the layout.

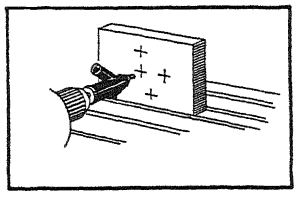
The Center Scope enables the operator to easily and quickly locate edges to a spindle axis, set-up faster and compensate for run-out It saves vital hours in checking, inspecting and measuring when mechanical methods and tools are impossible to use. Its 45 x magnification allows operator to see ".001" and requires no technical knowledge or training to operate.

While there is nothing particularly new or ingenious about Wrigley's Spearmint gum, it is proving useful to millions of people in many new ways. Workers in war plants everywhere have found it helps keep them alert and relieves nervous tension and dry mouth while they are on the job.

You can get complete information from the Center Scope Instrument Company, 351 S LaBrea Ave., Los Angeles, Calif., or Kearney & Trecker Products Corporation, Milwaukee, Wis



ON A VERTICAL MILL—locating and centering height gauge or size block layouts. Permits jig borer accuracy on more machines.



ON A HORIZONTAL MILL—the ability to center a layout, edge block or rotary table plug while spindle is running. Permits quick and easy set-up for high precision work.

Y-109

soaps in soil contact tests is attributable, at least in part, to the fungicidal properties of naphthenic acid.

"The relative protective values of different copper soaps may be expected to vary with the conditions of exposure of the treated fabrics. It seems possible that, for above-ground exposures, copper hydrogenated resinate might release sufficient soluble copper to provide good protection. In the case of above-ground exposures with conditions of heavy rainfall, the relatively low solubility and consequent slow rate of loss of total copper from the fabric might be a distinct advantage.

"The length of the service life of a treated fabric exposed to attack by micro-organisms may also be influenced by mechanical stresses, by photochemical deterioration, by direct chemical reactions between the preservative and the fabric or between the preservative and other finishing agents, and by other factors.

"In warm humid climates or in such cases as fabric tests in contact with soil, decay by micro-organisms may often be the most important deteriorative influence."

RAYON FIBER

Now Available in Finer Size

SUCCESSFUL development into commercial application of a "fine-as-silk" viscose rayon staple fiber of the "Avisco" or extra-strength type, is of immediate interest to a large part of the textile industry.

The new fiber is described by the American Viscose Corporation as 1.0 denier "Avisco" and is produced in appropriate standard lengths suitable for the different spinning systems on which it is used. Basically, it is said to permit spinning yarns of far finer sizes than heretofore possible with standard type rayon staple fibers. In addition, it materially increases the strength of spun rayon yarns and fabrics as compared with the yarns and fabrics made with standard type viscose rayon staple fibers.

Commercial applications already reported include flat knit fabrics, simplex glove fabrics, tricot knit dress goods, fine broadcloths, foundation fabrics, and various types of sheer handkerchief, dress, and shirting materials.

As a result of the availability of the new fiber in commercial quantities, it is predicted that the use of spun rayon in new fields, in new types of fabrics and new products, will be considerably broadened.

MACHINING CERAMICS

Speeded by Use of Cemented Carbides

OVERSHADOWED perhaps by the phenomenal increase in use and performance of cemented carbide tipped tools in the machining of steel for war equipment, little has been known of the growing use of this material in the machining of ceramics.

Typical of some of the developments along this line are applications now accepted as standard in the Porcelain Department of the General Electric Company. Here tools tipped with Carboloy cemented carbide are used for three different classes of work· For turning unfired insulators on lathes; for drilling and counterboring unfired insulators on drill presses; for dies for

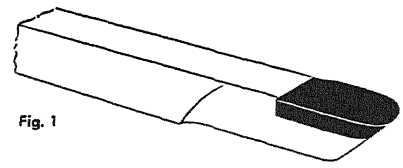


Fig. 1

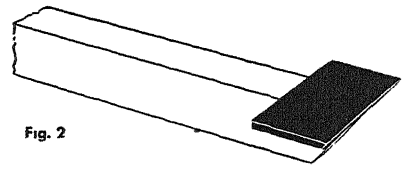


Fig. 2

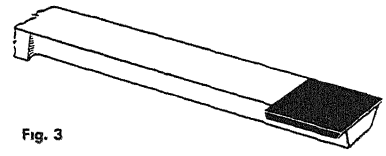
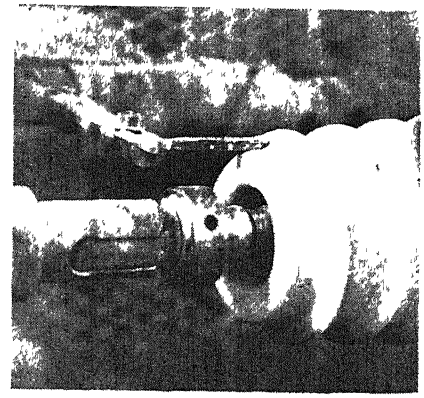


Fig. 3

Above: Caroboly tools for machining ceramics; (1) for grooving, (2) for counterboring, and (3) another type for use on semi-automatic lathes. Below: Turning a porcelain insulator



pressing insulators made of highly abrasive materials.

The first application is by far the most common. Formerly, with steel tools, it was necessary to take the tools out of the semi-automatic lathes every half hour for sharpening them. With the adoption of carbide tipped tools, the life between sharpening was increased to eight hours.

About the same ratio of length of life between sharpenings has been obtained with Carboloy-tipped as against steel counterboring tools. Contrary to the practice in machining metals, it is possible to have the tips on these tools have very little support below them, and the tips actually extend well beyond the "holder" each side of center.

Recently, Carboloy cemented carbide dies have been employed for pressing insulators used in the manufacture of vacuum tubes. While experience is not quite as broad on this type of service, over 75,000 insulators have been pressed with no signs of appreciable wear on either the pins or die cases. When steel pins and dies were employed it was usually found necessary to replace the dies after about 20,000 insulators.

Prime reason for the growth in popularity of carbides in the processing of ceramics is its tremendous resistance to abrasion. In this respect it departs somewhat from experience with this material in metal-cutting, where extreme hardness is probably its most important attribute.

MATERIALS BATTLE

Plastics and Light Metals Not Serious Menace to Steel

THE POST-WAR steel industry will not be seriously menaced by the light metals—aluminum and magnesium—or by plastics, Dr. John M. Weiss, New York industrial chemist, says in a report to the American Chemical Society. Nor will the very substantial percentage growth in the use of plastics be a marked hindrance to light metal development, he holds Progress in the full utilization of light-metal production will, however, be slow, he warns.

The estimated capacity figures for aluminum and magnesium are 1,500,000 short tons of aluminum and 300,000 tons of magnesium, or only somewhat less than 2 percent of the projected yearly steel capacity of 100,000,000 tons, Dr Weiss points out.

"The impact of the light metals on the steel industry can hardly be expected to be as great as the usual effects of the rise and fall of the tide of business activity," he declares. "Competition and new needs may so stimulate the alloy steels as actually to increase production and thereby bulwark the steel manufacturers. The steel industry cannot be expected to surrender tamely to light metals, even to the extent of 2 percent.

"Plastics will also fight for recognition. Exact estimates of production are not available, but a safe top figure of present capacity would be less than 300,000 tons of plastics per year. Tonnage-wise, the synthetic plastics represent only about 15 percent of the projected light-metal capacity. Many uses of plastics, notably the protective coating field, are not competitive with the light metals Likewise, the transparent and colored specialty products do not fall into the competitive class, so that the extent of the impact on metal is even less than the tonnage figures indicate.

"It seems evident that the basic economic situations of plastics and light metals are quite different The production facilities for the light metals appear far ahead of immediate post-war demand, so that a considerable time will elapse before the gap is filled Plastics, on the other hand, with the lower tonnage base from which they start, should have an easier task and after a relatively short period of post-war recession may be expected to resume their pre-war upward trend."

New uses for aluminum and magne-

sium reaching far beyond the transportation field will be necessary if the plants are to continue to operate at capacity, according to Dr. Weiss. The light metals will have to justify their entrance into some broader line such as building and structures, where a small proportion of the total tonnage would afford substantial outlets, he says.

"The large war uses of aluminum and magnesium are in airplane construction and in incendiary bombs," Dr. Weiss points out. "The latter will disappear with peace and the former will undoubtedly be sharply reduced.

"Offhand, it might seem easy for the light metals to develop by intensive effort to a tonnage of only 2 percent of that of steel. Many statements have been published suggesting that the transportation industry could easily absorb it, based on the economy of low weight in such use. Transportation includes airplanes, autos, and trains.

"Airplane use will undoubtedly continue, but the scale will inevitably be far less, at least for an extended period, than during wartime, and hence can hardly be expected to take more than a fraction of the available capacity With automobiles, trucks, and the railroads, post-war expansion seems reasonable, owing to wear and tear on equipment and to pent-up replacement demand

"A goal of an average of 300 pounds of light metal per car or truck would appear optimistically ambitious. Even with a 5,000,000 unit market, this would only take 750,000 tons of light metals or a little more than one third of the projected producing capacity—a substantial bit, if it could be obtained, but a considerable period of time and trial will be needed to see the real extent of the possibility.

"The railroads have less than 2,000,000 freight and passenger cars in service, according to recent statistics. The replacement demand for equipment can hardly be expected to afford as large a potential use of light metals as the automobile industry. It has been stated that the projected aluminum capacity would give sufficient metal in four months to build replacements for all passenger cars now in use on the United States railroads.

"Light metals will, therefore, have to reach far beyond the transportation field to utilize the available production capacity. The road is not easy. Progress appears necessarily slow."

TOOLING METHODS

Speed Up Work, Reduce Scrap

MARKED acceleration of automotive assembly-line production, in response to war needs of recent months, has pointed up the value of the continuous application of the industry's tooling techniques to the big job ahead.

Developed and refined over 40 years of peacetime manufacture, these methods—now applied to fighters and bombers, shell and shot, tanks and cannon, and hundreds of other war products—are proving just as sound an investment for the nation today as they were in the mass production of automobiles and trucks.

The Automotive Council for War Production cites several recent statements revealing a vast step-up in production, based on the solid groundwork of tooling needed for straight-line production.

One company, for example, was producing its third thousand bombers within eight weeks after production of the first thousand bombers had been announced.

Another company's production of 22,925 engines for Flying Fortresses in 1943 was nearly four times greater than the output of the previous year

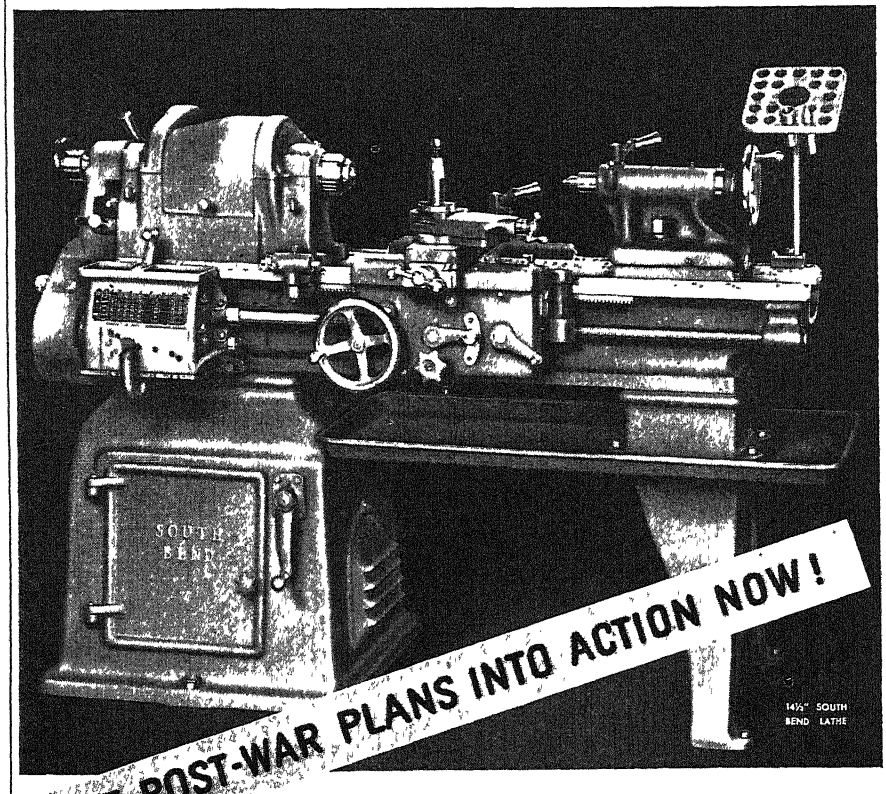
Thirty-three thousand engines for Liberator bombers have been turned out by another company, with 75 percent of these produced in the past 12 months.

Constant expansion and refinement of machine tools, jigs, and fixtures is one of basic reasons for such increased productivity, the Automotive Council says. It is a continuation of the peacetime practice to "do it better—do it quicker—do it oftener."

An instance of tooling up, and how it contributes to faster and more efficient production, is shown in the case example of the crankcase for one company's aircraft engine, whose output schedule was revised upwards three times The original small daily output schedule was met with a minimum of tooling, although each crankcase required 230 hours of work, and spoilage averaged 47 percent.

With the first big increase in production—an order that nearly tripled the daily output—the company quickly mechanized the crankcase operation Thirty-two new machines were purchased, along with their accompanying jigs and fixtures. Instead of 230 hours manufacturing time, only 125 hours were required for each crankcase, while scrappage was reduced to less than 7 percent.

Tooling refinements and expansion kept pace as production schedules were later doubled and then doubled again. Efficiency, too, continued to increase



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War production is still urgent—still our No. 1 job. But alert executives are now making plans that will permit a quick change-over to peace-time production. Many are already putting their post-war plans into action by placing orders for machinery to be delivered after the war is won. To help you order South Bend Lathes for post-war delivery, we have developed a practical post-war priority plan

It is only necessary that you place your order now—and in good faith. No deposit or down payment is required. Each order will be acknowledged by a numbered Post-War Priority Certificate. When civilian production is resumed, lathe orders will be filled as nearly as possible in the order established by the certificate numbers. The order may be cancelled at any time.

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What Strange Powers Did the Ancients Possess?

EVERY important discovery relating to mind power, sound thinking and cause and effect, as applied to self-advancement, was known centuries ago, before the masses could read and write.

Much has been written about the wise men of old. A popular fallacy has it that their secrets of personal power and successful living were lost to the world. Knowledge of nature's laws, accumulated through the ages, is never lost. At times the great truths possessed by the sages were hidden from unscrupulous men in high places, but never destroyed.

Why Were Their Secrets Closely Guarded?

Only recently, as time is measured; not more than twenty generations ago, less than 1/100th of 1% of the earth's people were thought capable of receiving basic knowledge about the laws of life, for it is an elementary truism that knowledge is power and that power cannot be entrusted to the ignorant and the unworthy.

Wisdom is not readily attainable by the general public; nor recognized when right within reach. The average person absorbs a multitude of details about things, but goes through life without ever knowing where and how to acquire mastery of the fundamentals of the inner mind—that mysterious silent something which "whispers" to you from within.

Fundamental Laws of Nature

Your habits, accomplishments and weaknesses are the effects of causes. Your thoughts and actions are governed by fundamental laws Example: The law of compensation is as fundamental as the laws of breathing, eating and sleeping. All fixed laws of nature are as fascinating to study as they are vital to understand for success in life

You can learn to find and follow every basic law of life. You can begin at any time to discover a whole new world of interesting truths. You can start at once to awaken your inner powers of self-understanding and self-advancement You can learn from one of the world's oldest institutions, first known in America in 1694. Enjoying the high regard of hundreds of leaders, thinkers and teachers, the organization is known as the Rosicrucian Order. Its complete name is the "Ancient and Mystical Order Rosae Crucis," abbreviated by the initials "AMORC." The teachings of the Order are not sold, for it is not a commercial organization, nor is it a religious sect. It is a non-profit fraternity, a brotherhood in the true sense.

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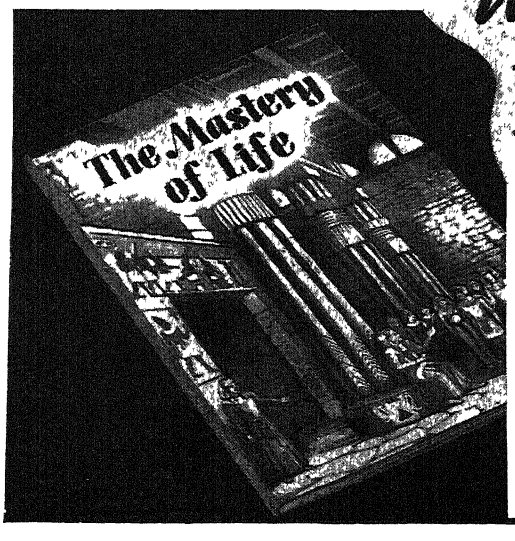
Sincere men and women, in search of the truth—those who wish to fit in with the ways of the world—are invited to write for a complimentary copy of the booklet, "The Mastery of Life." It tells how to contact the librarian of the archives of AMORC for this rare knowledge. This booklet is not intended for general distribution; nor is it sent without request. It is therefore suggested that you write for your copy to the Scribe whose address is given in the coupon. The initial step is for you to take.



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Machine time dropped first to 40, and finally to 32 hours, while scrap eventually reached the low point of less than 4 percent.

Meanwhile, the application of automotive mass production methods caused similar changes to be made throughout the entire plant.

Two especially designed boring mills were installed to accomplish simultaneously 18 operations formerly done individually. Production was increased 92 percent; nine regular boring mills were made available for other work Total production time for a complete engine eventually was cut in half, and scrap declined 80 percent

FIRE EXTINGUISHERS

Must Suit the Class of Fire to be Fought

EFFECTIVE "first aid" fire fighting requires the use of a suitable extinguisher on each different class of fire, of which there are three.

Fires in ordinary combustible materials, such as wood, paper, textiles, rubbish, and so on are known as Class A fires. They are best put out with water, which has a cooling and quenching effect. Extinguishers which contain water or chemicals and water are the soda-acid, foam, pump tank, gas cartridge and loaded stream types.

Vaporizing liquid and carbon dioxide extinguishers also are effective for controlling small Class A fires, if the fires are not deep-seated and if there are no strong air currents to dissipate the vapor or gas.

Fires in flammable liquids, grease and so on, are known as Class B fires Here a blanketing effect is essential, to cut off the oxygen supply. Suitable extinguishers are foam, vaporizing liquid, carbon dioxide, and loaded stream.

Fires in electrical equipment, Class C fires, require the use of extinguishants that will neither damage equipment nor convey an electrical charge along the hose stream to the operator Vaporizing liquid and carbon dioxide extinguishers are suitable for use on fires of this class. However, in some cases, fires in electrical equipment may be such that the quenching and cooling effect of large quantities of water is necessary. In such cases, the equipment should be made electrically dead before water or water solution is applied.

The Underwriters' Laboratories label on every approved fire extinguisher indicates the class or classes of fire for which that extinguisher is considered suitable and the number of such extinguishers considered necessary to comprise one unit of protection. Thus a 2½-gallon foam extinguisher is designated "A-1; B-1," meaning that it is approved for use on both Class A and Class B fires, and that one such extinguisher is required to make one unit of protection.

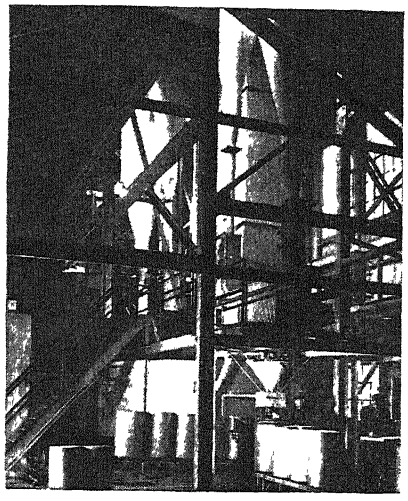
The number of units of protection required in any given location depends upon the relative severity of the incipient fire to be anticipated. The National Fire Protection Association recognizes three general classes of occupancies—light hazard, ordinary combustible

and extra hazardous. A guide for determining the number of units of protection required for each class of occupancy has been worked out For example, a place where fires of average intensity may be anticipated should have units so located that a person will not have to travel more than 50 feet from any point to reach the nearest unit, but at least one unit will be required for each 2500 square feet of floor area.

RESIN DRIER

Produces Powdered Adhesive for Easy Storage and Shipping

LARGER shipments of synthetic resin plywood adhesives to overseas points for on-the-scene assembly of barges and landing boats, and an ever-increasing domestic need for these adhesives for production and assembly of gliders, airplanes, torpedo boats, landing barges, pontoons, barracks, military truck bodies, skis, and snowshoes, account in part for the development by Resinous



Interior of the resin drier, showing the powdered material being packed

Products and Chemical Company of one of the world's largest resin driers.

This mammoth installation converts liquid urea-formaldehyde and phenol-formaldehyde resins by a new process into weight and space-saving powders that flow like water. Whether used here or abroad, the powder resins are permitting the use of lighter shipping containers constructed of non-critical materials, and this circumstance has resulted in great savings in shipping space. Most important of all, the powder resins have a storage life twice as long as liquid resins, a major consideration both in logistics planning and storage in plywood plants in this country.

POLISHING BOBS

Play Large Part in Engine Life

THE AUTOMOBILE industry's success in building aircraft engines on a mass-production basis is due in a large measure to skill of workers long accustomed to engineering tolerances of high accuracy.

An example of this may be found in the polishing departments of the Ford Motor Company's Highland Park plant and Rouge aircraft plant, where the scores of gears and rods used in 2000-horsepower Pratt and Whitney aircraft engines are finished to microscopic dimensions.

Due to the relatively high stresses to which aircraft gears are subjected, polishing to a microfinish is vital, since tests have proved that gear failures invariably occur where cutting-tool marks or scratches exist.

In view of the exactness and quantity of polishing necessary for the mass production of aircraft parts, Ford has expanded facilities for the manufacture and reconditioning of tens of thousands of polishing bobs used in this task. At the present time 139 different sizes of polishing bobs, ranging in diameter from one half to four inches, are manufactured and resurfaced.

Approximately 80 women are employed daily in this work at the Rouge aircraft plant, while half that number are similarly occupied at the Highland Park plant. Their combined output averages about 24,000 polishing bobs daily. All the polishing bobs are made of pressed felt. The women work in pairs, and while one holds the bob on a wooden mandrel, the other applies a quick-drying cement to the proper surface. Then the woman holding the mandrel agitates the bob in a tray of special abrasive. The bob is then placed in a medium oven, baked for four hours, removed, and a second coat applied. It is baked a second time and is then ready for use.

The abrasive used is made from slag and is purchased in great quantities, as much as 11 tons per month being used on one grinding job. Artificial abrasive has replaced emery dust because of its greater all-round utility. The rapid drying cement used by Ford is made by a secret formula developed by an outside company. Unlike the hot glue formerly used for this purpose, it does not melt under heat of friction; the abrasive life of the bobs is thereby extended.

PIG DE-HAIRING

Now Accomplished by Chemical Means

A PLASTIC covering that removes all the hairs from a pig when it is peeled off has given the housewife more high-grade pork cuts, ham, bacon, lard, and other pork products, according to Hercules Powder Company.

The chemical shaving method, which has been adopted by meat packers, also saves processing time and reduces dehairing costs.

Coating the pork carcass with a resin called Brisgo, packers now get rid of the toughest whiskers and stubble in a simple stripping operation. The pig is dipped into a tank containing the chemical and is then carried on the dressing conveyor to an operator who slits the warm plastic suit and unrolls it. In another method, the chemical is brushed on and scraped off. The removed plastic goes back to a remelting tank and is used over and over again.

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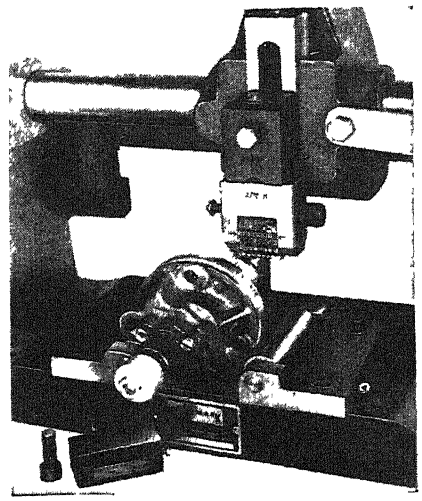
New Products

CURVED-SURFACE MARKER

COMBINING of standard fixtures in a regular No. 9A Acromark machine enabled a large manufacturer of aircraft equipment to speed up the marking production of curved parts without increasing personnel. By installing a set of standard non-adjustable cradle rolls and a socket-type mandrel fixture to



A mark for every stroke

support and locate the part in the proper marking position, the marking of a peculiarly shaped unit was accomplished as the last operation after the unit was completely assembled and inspected.

When a numbering machine with a sight index control was placed in the marking head of this machine and adjusted to the proper marking depth, a part was easily marked at every forward stroke and one at every return stroke of the machine.

PLATING ON PLASTICS

IN A new process for metal plating on plastics, glass, and so on, it is claimed that stronger unity of bond between metal and base is obtained. The plating withstands impact, vibration, and extreme temperatures without peeling or blistering, to the limits of the dielectric itself, which is greatly strengthened by the plating.

VIBRATION FATIGUE TESTER

AUTOMATIC cycling is obtained with a new vibration fatigue testing machine made by the All American Tool and Manufacturing Company. This new unit handles parts or assemblies up to 10 pounds in weight on a table eight inches square with holes drilled and tapped for attaching work to undergo test. The vibration mechanism runs in an oil bath.

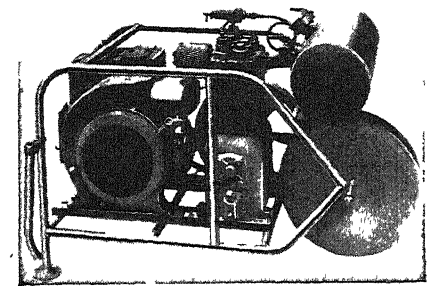
Vibration, in simple harmonic motion, is produced vertically. Acceleration, or rate of change of velocity, is controlled automatically by a device which changes the frequency from 10 cycles per second to 55 cycles per second and back to 10 cycles per second continuously and uniformly, the complete cycle requiring one minute. Acceleration can also be adjusted manually. Frequencies are accurately recorded on a sensitive electric tachometer.

Use of this device simulates vibration conditions actually encountered by parts in service and points out defects in design and construction materials.

WHEELBARROW TYPE COMPRESSOR

DESIGNED originally for the armed forces, many post-war uses are possible for a new, compact, wheelbarrow type air-compressor unit being manufactured by the Quincy Compressor Company. Weighing only 225 pounds, the unit is easily wheeled by one man Despite its small size, it incorporates a powerful, single-stage, air-cooled compressor with air delivery in excess of 16 cubic feet a minute at 80 pounds pressure.

Since this type of unit is primarily used at locations inaccessible to stationary or truck-mounted units, a number of features have been incorporated to overcome unfavorable outdoor conditions. Among these are the steel front wheel that is mud and water-proof and a belt tension adjusting device for easy starting of the gasoline motor in



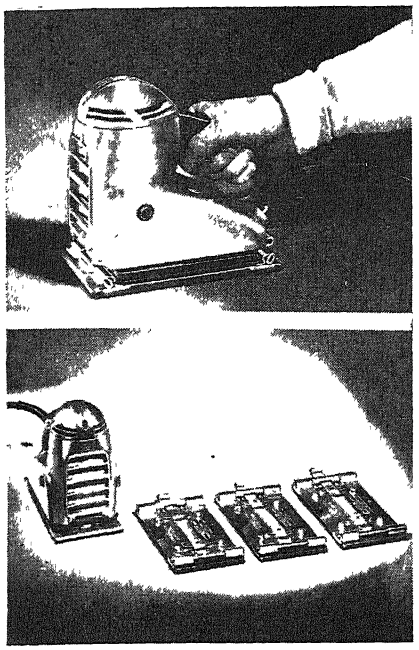
Easily handled by one man

cold weather. By means of a hand crank, the compressor load is taken from the motor during starting and the belt then tightened again for operation.

Among applications thus far found for the unit are exterior and interior paint spraying, camouflage work, emergency service to motorized units or airplanes, and in numerous construction operations.

DETACHABLE SANDING PAD

OUTSTANDING feature of a new Sterling electric portable sander is the flexible sanding pad which detaches from the machine by simply pulling out a latch. Several pads loaded with abrasives



New sander (top) operates easily with no pressure exerted by the operator. Detachable pads (bottom) make possible fast and easy exchange of various grades of paper

can be kept near work for quick exchange. When different grades of abrasives are used on a job, additional pads loaded with coarse and fine grits can be switched when necessary, thus avoiding the necessity for operator to stop work and reload.

The Sterling sander is especially designed to cover the entire range of abrading from coarse sanding to lapping and finishing. It provides fast and uniform cutting on wood, metal, and plastic The sanding pad is flexible and will conform to convex or concave surfaces of moderate curvature. Special pads for unusual contour sanding or rubbing are also available. The tumbler action locks on the sanding pad can be easily operated by a key that is furnished with the machine, or by a screwdriver. As tumblers are turned to lockup position, they draw in slack, pulling the sheet of abrasive taut on the pad.

Another feature is the non-vibrating action of the sander while the pad is moving at a speed of 4500 oscillations per minute. In fact, the vibration is so negligible that all the lettering on the nameplate (which is small) can be easily read when the sander is in operation. This smooth performance permits the operator to use it constantly with maximum comfort and to hold it with one hand from any position.

CHROMIUM DEVELOPMENT

TRIVALENT chromium, a long sought goal in the field of electroplating, has now become an established fact. By means of a new process, developed by Warner Laboratories, and a new chromium salt known as "Skalite," procedure for both hard and decorative chromium has been simplified. Plant investment is immeasurably less; the need for special chrome plating equipment has been eliminated. It is claimed that the Warner method is simple and automatic, not greatly different from copper plating.

Time, electrical energy, and salts required are only 20 percent of those for the old process. Due to the bath's non-gassing characteristics and substantially increased throwing power, there is no need for special contour anodes on intricate objects. Also, the bath is non-corrosive and non-poisonous.

SYNTHETIC-RUBBER GLOVES

TWO STYLES of industrial gloves made from synthetic rubber, now being manufactured by The B. F. Goodrich Company, can be sold to anyone who can qualify for such items under Rubber Order R-1.

One of the gloves is a light-weight type, 10½ inches in length. The second glove is of heavier construction, 14 inches in length. The heavier glove is available only in the straight-finger style.

Sizes and weights of the two types were carefully worked out to meet the greatest average demand, the company's announcement says. It also declares that the synthetic rubber gloves are equal in most respects to those made from natural rubber. They are as good as natural rubber gloves in resistance to acids, and at the same time are grease and oil-resistant.

The company offers a tip on synthetic rubber gloves which have been packed for a long time and which look wrinkled and stiff when unpacked. All their normal snap and life will reappear if they are held under warm water for a few minutes.

SELF-POWERED VENTILATOR

A PORTABLE self-powered ventilator, developed by The Herman Nelson Corporation, is primarily designed for use in cooling the interior of aircraft during repair work in hot climates; several other applications have been evolved by the necessities of war, and many civilian uses are anticipated.

The unit consists of a pressure-type fan, driven by a small gasoline engine or electric motor connected to a collapsible canvas duct through which the air is propelled to the area to be ventilated. Air delivery at 3400 revolutions

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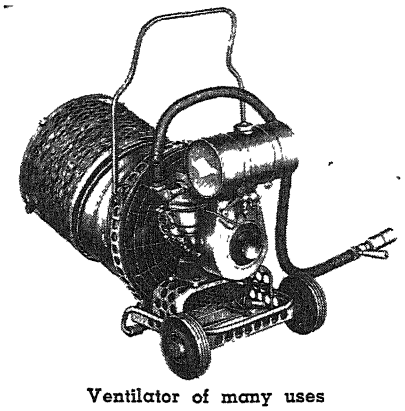


Ventilator of many uses

per minute is 4500 cubic feet per minute, without duct assembly attached, and 4000 cubic feet per minute with duct assembly attached The whole unit, mounted on wheels, is 24⅝ inches high. Weighing 87 pounds, it can be wheeled easily by one man and lifted into the interior of a plane when it is desirable to use the ventilator without the duct or to ventilate a distant compartment.

In addition to its use on aircraft, where it either blows outdoor air into the plane or exhausts hot air from the interior, the unit has been found useful for drying out the bilges, engine rooms, and double bottoms on boats, for driving out gases and fumes from confined spaces and, without the duct, as a man-cooler and repellent of winged insects.

HYDRAULIC PULLER

RECENTLY introduced by Templeton, Kenly and Company, the Simplex Jenny center-hole hydraulic puller was designed to accomplish in minutes many production, maintenance, and repair jobs which normally require hours.

This unit is being used for many tasks in general industry, construction, shipbuilding, mines, railroad shops, and in the oil fields. It has also been used for pulling in utility service pipe. Applications include pulling bushings, cylinder liners, cutless bearings, pistons, wrist pins, valve seats, keys, wheels, sprockets, gears, boiler tubes, and pipes, and pulling structural members together for welding or riveting.

The Simplex Jenny pulls, pushes, or lifts; and can also be readily rigged up as a portable press. This self-contained unit operates vertically or horizontally without the need for heavy auxiliary equipment, and without side thrust or friction. The Jenny is its own back-up and is self-supporting because of its center-hole construction.

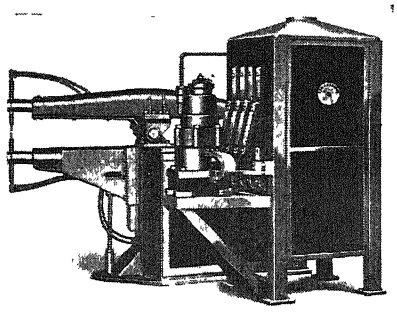
New hydraulic puller at work

Five models are available, of 30 to 100 tons capacity, all of them light in weight in proportion to capacity. Three models have single pumps and two have high- and low-speed pumps which may be operated separately, alternately, or together.

STORAGE-BATTERY WELDERS

WHAT IS believed to be the first practical direct-current resistance welder using storage batteries as a source of welding current has been announced by Progressive Welder Company, and is now in use for welding aluminum in aircraft assemblies.

Actually, the use of batteries as a source of "stored energy" for resistance welding involves no radical re-design of already available welding machines, since modified types of welding machines or guns may be used in combination with the storage-battery power



Batteries furnish the power

unit. The only requirement is sufficient power to operate a battery charger.

Development of storage-battery operated welders has been predicated on two new developments· The creation of a special battery design which will withstand high repeated discharge rates and the development of a contactor-controller which will control and interrupt enormous amounts of current, if required, without arcing.

Power to keep the batteries charged is supplied from a normal power line, either single- or three-phase A.C. The charger is of the dry-disk rectifier type, provided with automatic controls, and normally requires no attention. At the welder itself only a simple (non-synchronous) sequence welding control is needed. This, together with an automatic pressure switch on the welder and a "starting" pedal-operated switch, controls the weld cycle. Control of the actual amount of welding current is furnished by the contactor-controller The latter is capable of making and breaking tens of thousands of D.C. amperes at low voltage without arcing, and of controlling the current with but one single adjustment—that of pressure. Its principle is that of the well-known carbon pile, although pressures in the contactor may be as high as 25 tons when welding aluminum, for example. Usual factory air-line pressure is sufficient to provide this pressure.

Metals in Industry

(*Continued from page* 201)

tolerances. For the closest tolerances, screw machine parts are best and you may be sure the post-war engineer, intent on reducing vibration and noise and on guaranteeing perfect interchangeability on a million-part basis, is going to insist on ±0 001 inch or better in many engine, transmission, and general machinery components

Where loads are heavy or dynamic stresses severe, forgings will be favored. Forgings may have tough post-war competition with die castings or plastic moldings for non-structural consumer-goods parts but their use should increase in the industrial machinery and vehicular fields. Sand castings, too, are better engineering materials than formerly and will be employed for load-bearing jobs more than in the past.

Precision casting and powder metallurgy are still more specialized in their applications than most persons realize. The former is ideal for making small parts of metals with very high melting points, complex shapes, and narrow dimensional tolerances. Powder metallurgy excels chiefly for very close-tolerance work on a reasonably large-production basis, where considerable machining would be involved in making the part by conventional methods. On the other hand, recent improvements in powders, press sizes and speeds, coining practices, and so on, continually permit the attainment of closer tolerances or higher production rates or better mechanical quality than was considered feasible for a given part a while ago.

The pressure of supply on the aluminum and magnesium market is certain to result in an increasing use of die castings made of the light metals, while the use of zinc die castings should resume the steady growth it consistently enjoyed in the ten years before the war. One can see nothing but cheer ahead for those interested in die casting.

As a matter of fact, all the forms discussed here, plus a few others (magnesium extrusions, for example, and metal spinnings) would have bright futures if their present performances are any criteria. The important thing to remember is that war throws our economics all out of gear and that no 100 percent accurate appraisal of the rival methods will be possible until a more competitive era re-focusses our attention on such things as prices, material costs, labor charges, and so on.

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POWDER METALLURGY

Expansion Must Come from Unexpected Fields

THE POWDER metallurgy field has reached (probably passed) the peak of its war-time development and any future expansion of the industry must come from directions as yet unexplored. That is the basic conclusions to be drawn from a review of recent developments in powder metallurgy written by Frances H. Clark of the Western Union Telegraph Company for *Mining and Metallurgy.*

After an astonishing flurry of interest in it one or two years ago, the process has found its place on a somewhat smaller scale than many expected. Ordnance methods are now established and the Government's insistence on thorough testing and certification of new designs and processes for reasons of military safety has tended to bring the "ordnance expansion" phase of powder metallurgy's development to a close. Cost factors limited this expansion, too—for example, although high quality rotating bands for projectiles have been successfully made from sintered copper or brass powder, tubing manufacturers could still produce the bands more cheaply by sectioning copper or brass tubing, and the latter method continues to be the one used.

On the other hand, powder metallurgy parts of high density (that is, of low porosity), where machining costs are sizeable by ordinary production methods, have shown a moderate but steady increase in use. Iron parts for an automatic weapon, carburized iron gears for an aerial camera, and bronze or iron bombsight parts are in production and have performed satisfactorily. The sole supplier for an iron pole piece used by the Signal Corps in a field telephone is using powder metallurgy methods.

HIGH ALLOY STEELS

Can Stand Competition With Light Metals

THE HIGH alloy steels (steels with more than 4 percent alloying elements) have a much brighter future than one might suppose after reading some current prophecies of a "light metal age" to come. So one concludes on reading a paper recently presented by S. M. Norwood of Electro Metallurgical Company before a meeting of the American Society for Metals.

Basic compositions of high alloys and stainless steel will remain much as at present, but small variations will be developed to have profound effects on properties. The greatest development in the near future will probably be with the high alloy steels of the heat resistant type, particularly those which are not only resistant to deterioration at elevated temperatures but which have mechanical properties surpassing anything available in the past, so far as stress rupture and creep resistance are concerned. The development of alloys for power units in the gas turbine is a trend of this type.

High-manganese stainless steels, which have mechanical properties comparable to, and corrosion resistance inferior to, ordinary (chromium-nickel) stainless steels, but which cost less than the latter, may be widely used for structural applications. As a matter of fact, a much wider use of high alloy and stainless steels may be expected primarily because of their high strength rather than their corrosion resistance.

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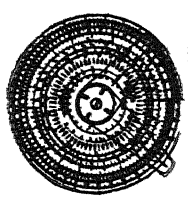

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OCCUPATIONS IN ELECTRONICS. by Forrest H Kirkpatrick and John E Crawford, is a six-page leaflet describing post-war opportunities in the field of electronics. The text covers the nature of the work, training required. probable earnings, distribution of employment, and other advantages and disadvantages. *Occupational Index, Inc., New York University, New York 3, New York.—25 cents.*

CHEMICAL NAMES AND TERMS is an eight-page pamphlet giving pronunciations and meanings of words peculiar to and frequently encountered in the synthetic rubber industry. *Hycar Chemical Company, 335 South Main Street, Akron, Ohio.—Gratis.*

WHAT YOUR TOWN NEEDS FOR THE COMING AIR AGE is a 36-page booklet directed to all civic-minded citizens and officials of municipalities in the United States. It discusses in a sane, practical manner the problems of aircraft landing facilities which will be so important in the post-war era. *Piper Aircraft Corporation, Lock Haven, Pennsylvania.—Gratis.*

FACTS ABOUT PLASTICS is a 24-page non-technical booklet covering all types of plastics, their properties and uses, and general information on the plastics industry as a whole. *The Richardson Company, Department 100, Melrose Park, Illinois.—Gratis.*

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Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

NOVELTY for novelty's sake can easily be argued down by cold logic but, who wants to be too logical when a hobby is involved? Recently your scribe, in mining down through the Archeozoic strata of a desk filled with many years' accumulations of telescoptical lore, in search of an elusive file of papers, hauled out the following item dated 1939. No apology is offered for its age; some ageless and fascinating items lurk in the same place.

The present little item came from C. H. Helm, an electrical engineer, Blidahlund 1, Chrl., Copenhagen, Denmark. He says he bought "A.T.M." in 1928, when living in the U. S., made a 10" Cass, returned to Denmark, forgot optics for 9 years, then made five concave grating mirrors for the Academy of Science at Stockholm, made a Fabry-Pérot interferometer for the University of Lund, with mirrors worked to 1/50 wavelength (and sends a ronchigram to prove it), also made two mirrors to 1/50 wavelength for the famous Danish physicist Bohr.

The idea offered by Helm is shown in the figure—a modified Gregorian for terrestial use. *A* is the usual paraboloidal primary. *B* is a secondary, also paraboloidal and adjusted to return the rays as parallel light *CD* is a small telescope, like field glasses, adjusted to infinity. The parallel lines represent a tube to exclude extraneous light. "It works all right," Helm reports. He reports also that "A.T.M." is "the best book ever published on any one subject," which may be slightly hyperbolic but is pleasant to hear.

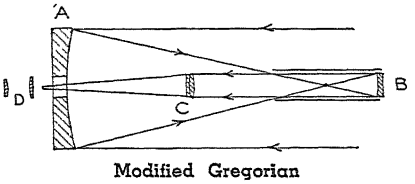
Commenting on Helm's ideas, N. J Schell, Beaver Falls, Pa., says· "Have never seen just this before, but the secondary acts similar to an erecting lens if used in this fashion The rays would be parallel to the axis only on an object in line with the axis, all others being inclined from the axis at angles corresponding to the entrance (or incoming) angles. This would tend to limit the extent of the field to the proportions of the secondary. The arrangement would serve somewhat along the lines of Dall's 16" spherical Cass, which has the secondary focus between the mirrors, but since Dall's is á-la-Cass, the size of the field available would be larger with a given size of secondary. Dall's also gives an erect image.

"Two or three years ago, at the request of the late Dr. Palmer of Pittsburgh," Schell continues, "I suggested to him a Cass with secondary designed and figured to have a secondary focus at infinity, for a special purpose he had in mind. This has no bearing on Helm's design, except to indicate that the idea of infinity secondary focus, having occurred to me, probably has occurred to many others as well.

"However, if this has any advantage not readily apparent, it might be worth developing further."

One function of this department being to put ideas on public record, the above idea is hereby put on public record. In fact, not enough of those proposed to this department have been similarly put on such record—they hide in special files of old letters in the above-mentioned desk, and every now and then some new worker rediscovers them and proposes them, which then sets in motion a search. The variety of telescoptical ideas hit on by amateurs during the past 10 years has been astonishing.

IN A TINY NOTE in this department in July, 1942, mention was made of the death of J H Hindle, co-author of "A.T.M." and of "A.T.M.A.," and promise of further facts was made. At long last, and despite the complications of the war, data have now come to light in the form of an obituary contributed by William Porthouse, of England, to the famous "M N.," or *Monthly Notices,* of the Royal Astronomical Society, principal organ of British professional astronomers Hindle was an amateur but, just as several amateurs enjoy membership in the professionals' American Astronomical Society, so was Hindle regarded by British professionals as properly belonging to both groups. The *Monthly Notices* is a magazine of scope, solid substance, abstruse depth and height, similar to our American professional astronomers' magazine, *The Astrophysical Journal.* The obituary:



Modified Gregorian

"John Henry Hindle was born at Edenfield, in the Rossendale valley of Lancashire, of Scottish stock, on 1869 November 2, and was elected to Fellowship of the Society on 1922 June 22.

"He was a shrewd Lancashire ironmaster, generous of heart and hand, with all the many virtues of his race: a man of robust intelligence, inexhaustible patience and infinite resource. At the date of his death he was the governing director of the firm of Hindle, Son & Co., Ltd, Engineers, of Witton, Blackburn, where he produced, based on his own and his son's patents, electric and other baling presses, and powerful wide looms for the weaving of cotton and woolen dryer felts for use in the paper-making industry. He was indeed the first person directly to apply electrical power to the generation of mechanical pressure for baling loose materials, and the convenience of this machine has been widely recognized.

"Apart from elementary education at the local school at Edenfield, Hindle was practically self-taught. At the age of 12 years he commenced work as a 'half-timer' in the textile industry, and upon leaving school at the age of 13 went into the mill office where his father was secretary and cashier. During this period he worked in an iron foundry and workshop in his spare time and developed very early his interest in engineering, particularly on the electrical side. About 1895 he had attained the position of electrical consultant on hoisting machinery and electrical motors and dynamos. He developed and patented automatic control gear, an electro-magnetic brake and an emergency safety mechanism for use in electric passenger and goods lifts

"In 1910 he courageously started in business for himself as a practical engineer in Manchester, removing in 1918 to Haslingden and afterwards to the present Union Engineering Works, Blackburn, where, with the assistance of his only son Thomas, who survives him, he built up a considerable business in textile engineering.

"As his major hobby the production of telescope mirrors appealed to him because of his love of the delicate and precise in science and art Although not physically a big man he had a wonderful facility in the handling of large specula. Some years ago he was described in the *Manchester Guardian* as 'one of the leading optical experts of the time.' He produced and mounted many Newtonian and kindred mirrors of all sizes, the largest being the 20½" made for Dr. W H. Steavenson, the 25" which he used himself for the delight of his friends, and the 30" which is being mounted at the Cambridge University Observatory by arrangement with Sir Arthur Eddington. This instrument is to be available for the Observatory staff until such time as Dr. Steavenson is free to put it to full use. It is described in detail by Hindle himself in *Scientific American* for 1939 September. Notwithstanding the magnitude of these instruments Hindle always considered himself a 'pure' amateur, never profiting financially by his hobby, but always shrewdly placing his telescopes where he knew they would do the best work.

"His principal contributions to the craft were·—(a) 'The Compound Telescope—Cassegrainian and Gregorian Types.' (b) 'The Mechanical Flotation of Mirrors.' (c) 'How to Make a Diagonal for a Newtonian Reflector' (All appearing in permanent form in 'Amateur Telescope Making' and 'Ama-

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teur Telescope Making—Advanced.')

(d) 'A New Test for Cassegrainian and Gregorian Secondary Mirrors.' (*M.N., 91,* 592, 1931.)

"This new test was considered by Professor Sampson to be a great improvement on other practice, and led to Hindle's being commissioned to make a new 19½" convex secondary for the 72" reflector at the Dominion Observatory, B. C, to be subjected to the new test. I cannot find, however, that this convex was actually completed.

"Hindle designed his own 'ovoid stroke' grinding and polishing machine but refused to patent it. It is described in 'Amateur Telescope Making' and has become justly popular in the United States of America. A machine of its type is installed at the Kyoto Imperial Observatory, Japan.

"Hindle was a world-wide traveler His unique business took him constantly to the Continent. He visited South Africa, the United States, and Canada, the last two on many occasions. At such times he always made it convenient to visit the great observatories, where his acquaintance with the optics of reflection made him persona grata with those in control. He was present at the pouring of the 200" disk for the Mount Palomar reflector, an experience which he afterwards described to the present writer in vivid phrases and good Lancashire accent.

"Hindle died at his home in Blackburn on 1942, May 17, at the age of 72. He is buried with his wife (who predeceased him by 22 years) in Helmshore churchyard and his memorial bears the simple inscription of his devoted daughter, who survives him: 'He helped them to look at the stars.'"

Your scribe recalls several protracted visits made by Hindle in New York for business purposes. The "good Lancashire accent" is closer to American than the so-called "standard" English.

He was a thick-set man who, despite his descent from Scottish stock, reminded one of the chunky, substantial John Bull of the familiar sketches, and he was a bit "set" His Scottish stock came to the surface in a long but exceedingly lively argument which he conducted with Ellison in *English Mechanics* in 1926, regarding the effects of changing temperature in telescope mirrors. In issue after issue the Englishman of Scottish descent and the sometimes peppery Irishman of Scottish-English descent did major combat, barring no holds. Your scribe still has most of these serial communications—a dozen rounds of pitched battle, each provocative of many a chuckle—preserved in a treasured file clipped from *English Mechanics.* Few of us are wholly logical when it comes to higher authorities. We incline to place them beneath the haloes of saints. Most of them would prefer to be regarded only as people, and these two were very human.

CYRIL G. WATES, 7718 Jasper Ave, Edmonton, Alberta, Canada, writes:

"With reference to J. R. Haviland's note on the Barlow lens in the September, 1943, issue, the following points may be of interest. The amplifying power of any Barlow is given by the formula $A = F\text{-}d/f_1\text{-}d$, using the same notation as in Haviland's equations. The focal length of the lens is the principal factor in determining the amplifying power.

"While it is true that the position of the lens has some bearing upon the magnification, the result of moving the lens within reasonable limits is very small. In the example given the lens is placed 2" inside the prime focus, giving an amplification of 4. With the lens 1" inside prime focus, A is 3.8; with the lens 6" from prime focus, A is 5.

"As a rough method of determining the correct focal length of the Barlow lens and its position in relation to the prime focus, the following formulas are approximately correct. No exact formula is possible, since each factor depends upon the other

$$f_2 = 3f_1/2A$$
$$d = f_1\text{-}f_1/6A$$

"The 'power' of spectacle lenses is given in diopters, and the amateur who wishes to experiment with a Barlow lens purchased from his local optician should ask for a negative lens of 39.4 divided by f_2 in inches"

READERS of this department have inquired about the cause of rough, porous, or flaky aluminum coatings that have sometimes been found on telescope mirrors. The question was submitted to an outstanding authority on aluminizing and he replied that this is often a case of what he called "measles," due to faulty cleaning of the mirror before it is put into the jar for coating, or to greasing up in the "evaporatus" after the mirror is put in before mirroring.

An independent means by which the recipient of an aluminized mirror may evaluate the job done consists, as described in a private communication from the authority just mentioned, in pressing a little strip of scotch tape onto the edge of the aluminized surface. If the latter is correctly mirrored the scotch tape will not, when pulled off, remove any of the aluminum film.

On the other side of the question, some who have aluminized mirrors have been blamed unjustly for imperfect coatings of another type, that were caused by pits left in the polishing by the mirror maker himself. Many mirrors—a very great many—especially first ones but sometimes subsequent ones, are not polished out No aluminizer can be even remotely expected to cover over these faults; in fact, the coating will make them appear to be much more prominent than they appeared before.

Those, also, who hurry the aluminizer, asking immediate return of the mirror sent him, run risk of receiving a case of measles, especially if the job has been done in damp weather, when there is a tendency for oil to creep into the chamber. The disease does not always appear at once but may have a gestation period of a few days. If, therefore, the aluminizer is given a few days to age the mirror before he ships it back, the latent measles, if any, may show up and be cured by recoating.

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COVER. In the manufacture of even such small and apparently unimportant items as nuts, it is necessary that exact control be maintained over the materials used if the resulting product is to be of uniform high standard Shown in our front cover illustration is part of the chemical testing laboratory in one of the plants of the Elastic Stop Nut Corporation of America Here all incoming raw materials are tested for conformance to rigid specifications before they are processed

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Previews of the Industrial Horizon

By A. P. Peck

TRANSMUTED WOOD

POPLAR that is as hard as hard maple, hard maple that is hard as ebony, commercial uses of wood formerly unfit for such applications because of inherent deficiencies in strength or grain structure, are some of the possibilities that arise from a new wood treatment process developed by Du Pont. Add to these qualities of increased hardness and strength the fact that the treated wood will not swell or warp under changes in humidity, and the industrial applications of "transmuted" wood broaden tremendously

Briefly, the transmutation process consists of impregnating the wood structure with resin-forming chemicals capable of reacting with the wood cellulose. This reaction profoundly alters the properties of the wood. It becomes harder—much harder, stronger, stiffer, and the grain will not rise on wetting The wood so treated can be more smoothly worked and highly polished without the further use of surface finishes. Its tendency to shred or splinter during working or later use is vastly reduced. An an added feature of the process, color can be introduced during the impregnating process, resulting in wood that is colored throughout its structure.

Wood treated by this methylolurea process is no longer wood in the commonly accepted sense. It is transmuted to a product in which the wood structure carries a hard resin. All the beauty of the wood grain is retained, however, with added beauty gained through the polish which can be achieved.

Within reasonable limits, it appears that the possibilities of wood transmutation with methylolurea are virtually boundless. Furniture made with treated wood will retain its shape, drawers will not stick; veneers can be made harder, and self-bonding if the base is also treated; doors and jambs, window sashes and frames, will not swell or shrink; wooden parts subjected to wear—loom shuttles, for example—can be given greatly extended life

Not the least important feature of the transmuted wood is the surface finish Scratches in furniture and the like can easily be removed by simple sanding and repolishing of the affected area; it is unnecessary to refinish the entire surface, since the finish is "built in" through the entire thickness of the wood.

From the commercial angle, it should be noted that the process is inexpensive, both as to materials and treating equipment. In fact, it might be said that it will be, in some cases, "costless" because it decreases waste, makes rejected wood available for use, prevents shrinkage, and reduces finishing operations.

Indications so far are that treated woods require slower rates of sawing, cutting, and turning and that different tool settings and harder tools or more frequent sharpening are necessary than with untreated wood More power is needed for drilling or for inserting screws, but the holding power of screws and nails seems to be improved

GASOLINE TOMORROW

PERHAPS no war-necessitated rationing has given birth to more discussion—and more misconceptions—than that applied to gasoline. Forcefully has it been driven home that this is a petroleum war, a war in which motor fuel is as vital a fluid as the very life blood of the men who are doing the actual fighting.

From this dependence upon petroleum products have come, of course, technological developments in motor fuels that foreshadow important news for the motorist. Much of the present work is still in the hush-hush stage, but enough of it can be talked about to furnish a glimpse of the horizon Thus Dr. Alexander Klemin looks over the motor fuel situation, from the standpoint of aviation, in the article on page 262 of this issue; on page 268 Thomas H. Risk views it as an oil-refinery technologist; D. H. Killeffer considers it, on page 247, as a problem to be tackled by the chemical industry.

Here is a truly complicated industrial problem, one which presents so many facets that at the moment much of the thinking about the future must be considered as factually-based speculation. Two of the aspects will have to work themselves out as time rolls on What will be the source of gasoline tomorrow? What will be done with the high-octane gasoline refining equipment already in use and that under construction?

Some answers are fairly clear today, and they all sit squarely in the lap of industry. First, the chemical industry must make itself responsible for increasing efficiency of gasoline manufacture and for developing new fuel sources. Then the automotive engineers must take it upon themselves to make possible the utilization of the maximum power of this fuel. The growing aviation industry also comes into the picture, with a share in the development of still better power plants and expansion of commercial air transportation.

If nothing else comes out of the building of huge gasoline production facilities two things are sure: The world is learning how to make the most efficient use of irreplaceable oil reserves; other methods of obtaining liquid fuels than from crude petroleum are being vigorously investigated and developed

TELEVISION FILMS

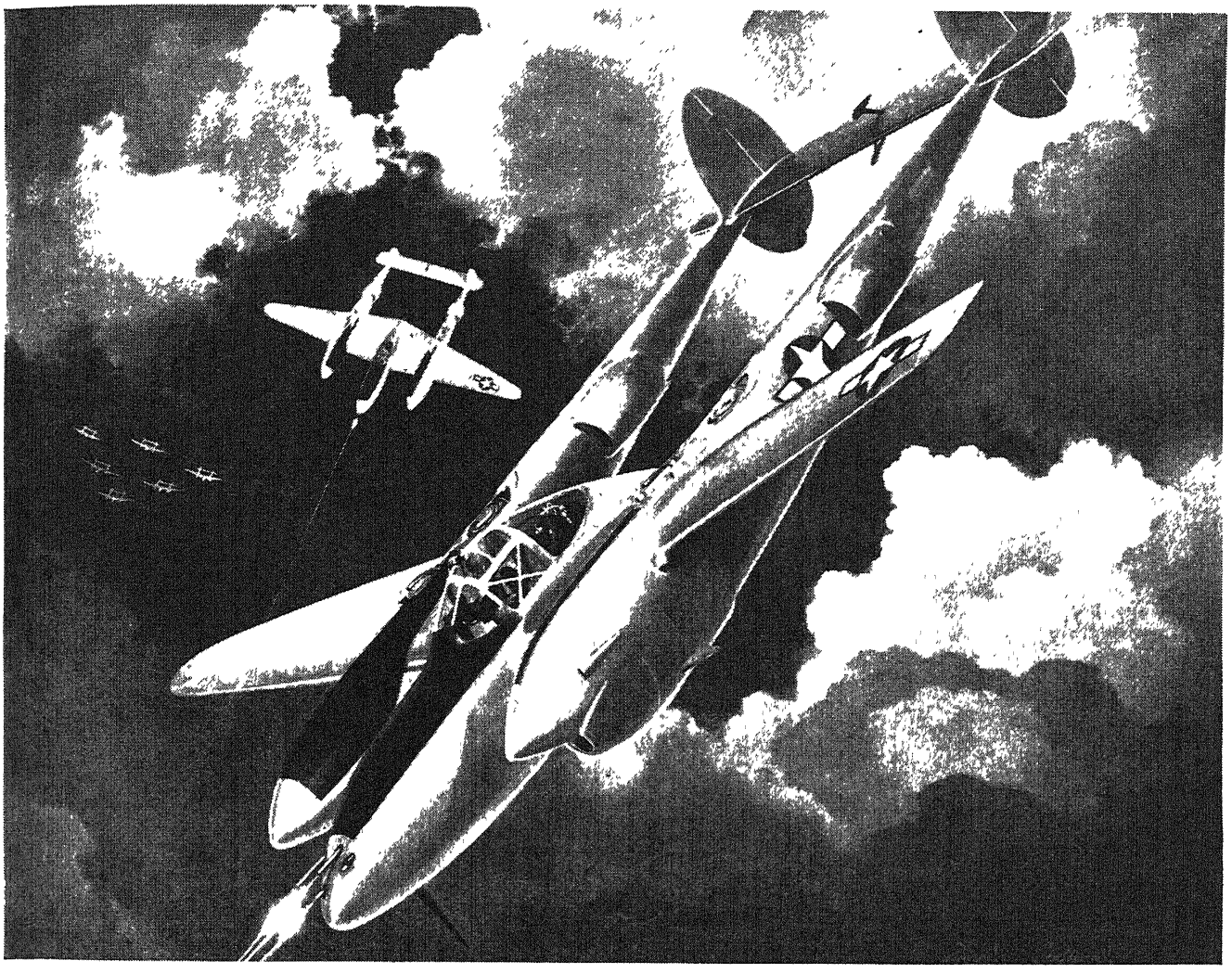
LOOK TO television to make great demands on the film industry when it once gets under way While "live" programs will undoubtedly be largely used in video broadcasts, mainstay will probably be movie films. As the number of television stations increases—and G E. estimates that there will be 100 active stations within five years after the war—there will be need for an enormous number of movies to fill the requirements for anything like consistent television service.

OFFICE EFFICIENCY

ALL TOO little realized is the fact that office work can be speeded up, made more efficient, by the very same methods as have so successfully been applied to shop operations Time and motion studies have shown startling facts about routine office procedures Steps taken as a result of such studies have been highly productive in increasing output, reducing waste, and making office employees happier, once they are shown that the steps are for their own benefit as well as that of the firm

FOR FUTURE REFERENCE

BUSINESSES that are now lining up customers for goods to be delivered as rapidly after the war as conditions permit will be the ones to get in on the peace-time ground floor .. Neoprene, oldest and most versatile of the synthtic rubbers, is now almost as scarce as natural rubber. But the varied uses to which it is being put, because of that versatility, are making it ready for great post-war applications. Over 70 percent of the metals industry of the United States can convert to peace-time operations almost overnight. . . Post-war products, in limited fields, are already making experimental models of magnesium, studying the advantages and disadvantages of this light metal. . . Greater travel comfort for railroad patrons is foreseen in research now going on in such matters as seats, luggage racks, wash rooms, window shades, and so on.



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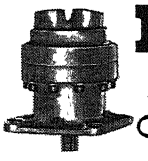

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SCIENTIFIC AMERICAN

(Condensed from Issues of June, 1894)

AUTOMATIC PILOT — "An interesting device by Mr Bersiei is described in *L'Ind Elec.* The object is to operate the rudder of large vessels automatically by the compass directly without the use of the usual seaman. . The standard compass is used and a current from a Ruhmkorff coil is passed from the pivot of the needle to the north pole extremity, whence sparks of 3 millimeters' length pass to one of two semicircular pieces of aluminum insulated from each other, the gap between them being set to the desired sailing direction. When the spark passes to one of these the current, by means of a relay, starts a motor in one direction, which in turn operates the rudder, while if the spark passes to the other piece, it moves the rudder in the other direction"

ENGINEER-ARCHITECTS — "The profession of architect as relating to the designing of buildings has occupied a position intermediate between that of a profession and of an art . But of recent years a new function has to be called in, in the construction of modern city buildings, which function is the work of the modern civil engineer. . Steel has now invaded the architect's realm, and the last few years have seen a new type of city building evolved, one which would be impossible without steel, and in which the modern engineer asserts his presence"

MATCHES — "The lucifer match has attained its present high state of perfection by a long series of inventions of various degrees of merit, the most important of which resulted from the progress of chemical science."

SUEZ — "Three thousand three hundred and forty-one ships, of 7,659,000 tons, passed through the Suez Canal in 1893, yielding sixty-eight millions in dues."

INSANITY — "Great intellectual effort requires high nervous tension. It is ability to stand this tension which makes greatness, and the vanity of greatness is merely the symptom of reaction—of breaking down, of the insanity which is the result of nervous tension uncontrolled by will."

COMMERCIAL FISHING — "The commercial fisheries of the country give employment to 182,407 persons, represent an investment in vessels, boats, fishing gear, buildings, wharves and other property of $58,355,000, and yield products of the annual value of $45,000,000 in first hands. The cost to the consumer is probably about $130,000,000, and it is thought that the fisheries of the whole United States furnish support to over 1,000,000."

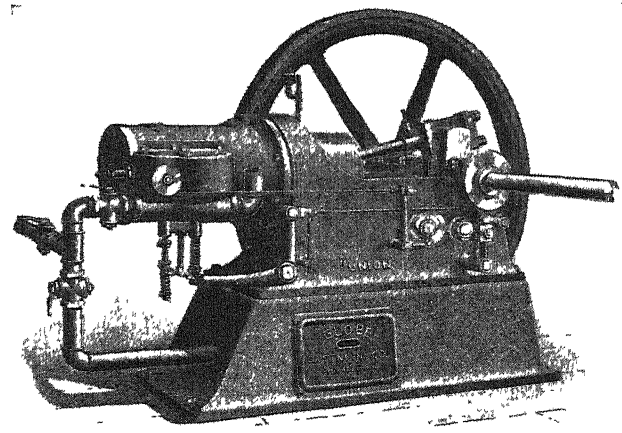
SEWAGE TREATMENT — "A practical application of electricity to sanitation has recently been made. . . Mr. William Webster . . . treats the sewage directly. He places parallel iron electrodes within a conduit or chute, through which the sewage is passed, the electrodes being alternately connected with the positive and negative poles of a dynamo. The nascent ammonia thus evolved at the negative electrode produces an alkaline reaction, which effects the precipitation of the solid suspended matter, while at the positive pole nascent oxygen and chlorine are evolved, producing an acid reaction, whereby the organic impurities held in suspension or solution are readily decomposed and purified."

DIAMONDS — "M. Moissan has not only succeeded in reducing the most refractory metals, but has fused and volatilized both lime and magnesia. Nearly all the metals, including iron, manganese, and copper, have also been vaporized, while by fusing iron with an excess of carbon, and then quickly cooling the vessel containing the solution of carbon in molten iron by suddenly plunging it into cold water, or better in a bath of molten lead, he has been successful in producing small, colorless crystals of carbon, identical in their properties with natural diamonds"

BEARINGS — "Ball bearings are successful only when the balls themselves are of the highest quality, and the shells and axles are of the best steel hardened and ground to the highest perfection. The limit of error in the best does not vary more than one-quarter of one-thousandth of an inch, or one-fourth the thickness of tissue paper"

ROOFS — "Flat roofs have several advantages, and can conveniently be constructed of concrete, with iron or steel girders at intervals If the under side of the concrete has to be the ceiling of the room below, it may be desirable that it should be quite flat In this case, the necessary falls and gutters can be formed with rough concrete laid on the top of the main body of concrete The best material for finishing such roofs externally is asphalt"

GAS ENGINES — "The gas engine has been recognized by engineers as affording one of the most efficient prime movers known. The steam engine is far more wasteful of the energy received from its fuel when steadily running. Irrespective of this fact, a further source of waste, which may be of still greater degree, is that for intermittent power much of the fuel in a steam boiler furnace may be burned uselessly . With the gas engine it is different The gas is turned off when the engine is to stop, and none of it is used until it



is wanted. . . The Globe Gas Engine Company's engines are built to work with both gas and gasoline. Perfect adaptation to the latter kind of fuel was shown in an experiment in which an engine was run for a long time with kerosene oil in place of gasoline The fuel is vaporized before burning, simple atomization not being relied on, and no heat is required for the purpose"

MATH — "Mathematics should be regarded as a kind of mental shorthand, a ready means for stating a proposition exactly; an instrument for recording thoughts so that they cannot be misconstrued. Mathematics is not essential to the art of theorizing, but it is essential to the art of theorizing rightly, it is the only economical method of thought."

LIGHTHOUSE — "The present Fire-Island light . . . on Long Island . . . is to be replaced by an electric light, said to be the largest ever made. It is claimed that it will have a brilliancy equal to twenty-five millions of candles. . . It is expected that the light can be seen a distance of 25 miles"

COAL TAR DERIVATIVES — "As a consequence of the progress made in the manufacture of coloring materials from coal tar, physiologists and physicians have been able to experiment with a host of new products, some of which have found a place as therapeutic or antiseptic agents. . . The number of organic bodies proposed as antiseptics or medicinal products is very large, and one or more medicaments are observed to make their appearance every day."

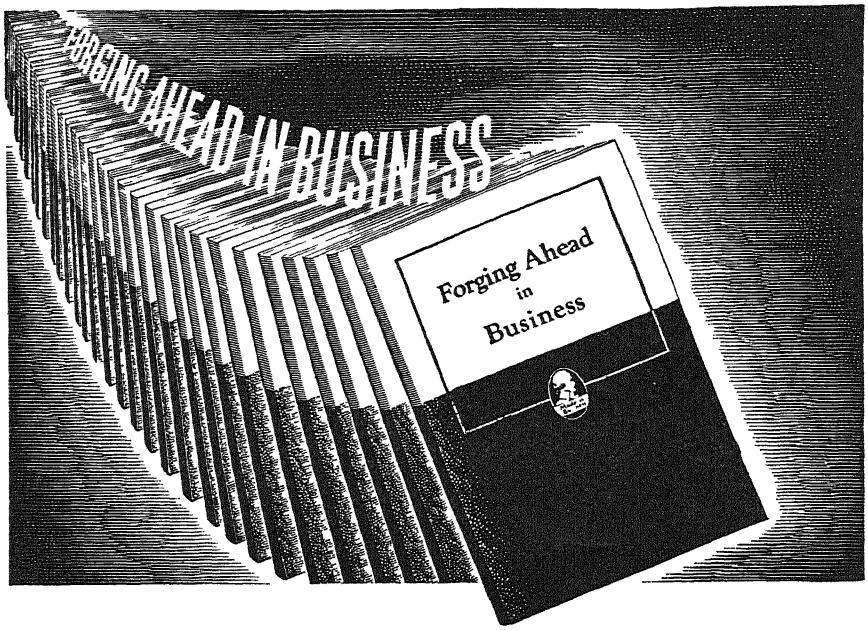
HELP HIM GET THAT

LONG DISTANCE CALL

THROUGH TONIGHT

You can do it by not using Long Distance between 7 and 10 P. M. Those are the night-time hours when many service men are off duty and it's their best chance to call the folks at home.

BELL TELEPHONE SYSTEM



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"Quotes . . ."

"IF AMERICA is to have enough jobs after the war we must encourage invention in small business. Invention and small business depend on patents Patents protect the little fellow from having his ideas pirated. They are the sling shots that make it possible for the little Davids to compete with big Goliaths" *R. J Dearborn, President Texaco Development Corp*

" " "

"THERE IS every possibility that before natural rubber again becomes available in quantity, we will have perfected a general-purpose synthetic able to compete with it on virtually even terms." George W Vaught, Vice President, B. F Goodrich Company

" " "

"BEFORE THE WAR the nation was dependent upon only high-grade domestic and imported bauxite for alumina. Today, using a process developed by Alcoa after 25 years of research, the industry is making alumina from low-grade bauxite and even the red mud residue from the familiar Bayer process." *Roy A Hunt, President, Aluminum Company of America.*

" " "

"IF THE NATION'S empty-bin boom is to be followed by growth and sustained prosperity, the flow of new capital into enterprise must be stimulated beyond any volume in our experience" John Clifford Folger, President, Investment Bankers Association

" " "

"THE HELICOPTER in the future, when many problems now existing have been solved, and solve them we shall, will bring our new Age of Flight within the reach of practically everyone. It is an individual machine more than a common carrier" *Colonel H F Gregory*

" " "

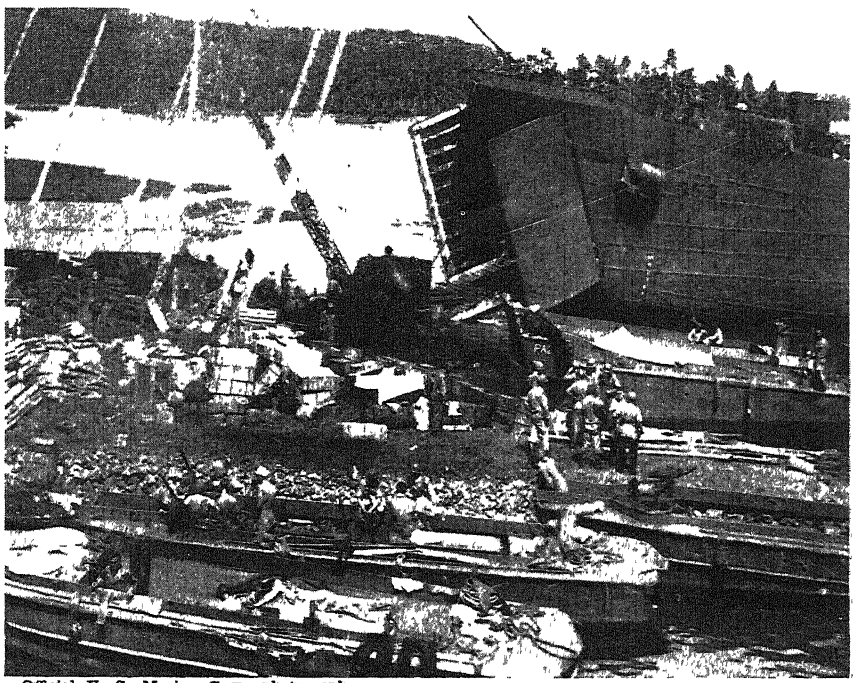
'THE WAR is disclosing new vistas American industry must gear itself to peacetime production on a scale without precedent. That is largely an engineering job. . A war-torn but industrially awakened world will require the service of engineers, not only for repair and reconstruction of its productive facilities, but also for a new productiveness." Robert M. Gates, President, American Society of Mechanical Engineers

" " "

"TELEVISION OFFERS the soundest basis for world peace that has yet been presented. Perhaps that will surprise you, but isn't this logical: Peace must be created on the bulwark of understanding. International television will knit together the peoples of the world in bonds of mutual respect; its possibilities are vast, indeed." *Norman D Waters, President, American Television Society.*

CHEMISTRY IN INDUSTRY

Conducted by D H KILLEFFER



Official U. S. Marine Corps photograph

Working on mosquito-infested jungle beaches, our fighting men cannot be hampered by protective nets. But chemistry is furnishing adequate protection with a new insect repellant developed by Carbide and Carbon Chemicals Corporation

Synthetics Offer Solutions

Some 160 Compounds Have Been Produced from Petroleum and Natural Gas. Many of these Will Become Essential Parts of New and Important Post-War Developments. Today the Processes Involved are Supplying War-Needed Products; Tomorrow They May be Applied to Liquid Fuel Production

ETHYL alcohol, required for synthetic rubber and a host of other war-connected applications, overshadows other alcohols in the news. That is as it should be. Only where troubles and shortages arise are headlines born. The chemical industry generally fulfills its duties so well in the war effort that few of its products or operations draw more than passing attention. The important alcohols derived from petroleum and natural gas, which are more numerous and useful than one might suppose, illustrate this fact

Following World War I, American chemists developed a new industry based on the manufacture of scores of useful products through chemical elaboration of the hydrocarbons abundantly available from American oil and gas wells. This native phase of the chemical industry now yields solvents, resins, aviation gasoline, and synthetic rubber among others, and has grown to rank with that of the older coal-tar chemistry, supplier of dyes, pharmaceuticals, and perfumes. Its orderly growth made it equal to the burden of the demands of the present war and hence it has attracted little public attention

Current production of synthetic rubbers and 100-octane gasoline, requiring huge volumes of oil, emphasizes the approach of a famine in oil as our petroleum reserves are progressively depleted To an important and growing extent our future supplies of motor fuel are destined to come from other sources, notably natural gas and coal. The shift will be gradual over a period of years and, during the transition, our reserves of natural gas will play an increasingly larger role as the first offset to depletion. Synthesis of motor fuel from gas will presumably precede the large-scale hydrogenation of coal to liquid fuel. The reason for this is the comparative simplicity of the gas-using processes and the fact that equipment and techniques for the purpose have already been designed and operated

Thus the present production of synthetics from gas and oil, useful and important as it is, assumes special significance in view of the prospective diminution in oil reserves. Here exist processes and plant designs—albeit on a scale far smaller than will be needed—capable of adaptation to the future's immense problem. Today they produce many products, especially alcohols; in the future they will be adapted to make gasoline.

Alcohol, the word, normally means ethyl alcohol, fermentation product of sugar, even though alcohol may come from other sources. However, the term also designates a large and important family of chemically similar materials. Most of these are less widely known since the quantities of them employed in industry are tiny by comparison. Nevertheless, their functions are vital in many diverse ways. The alcohols

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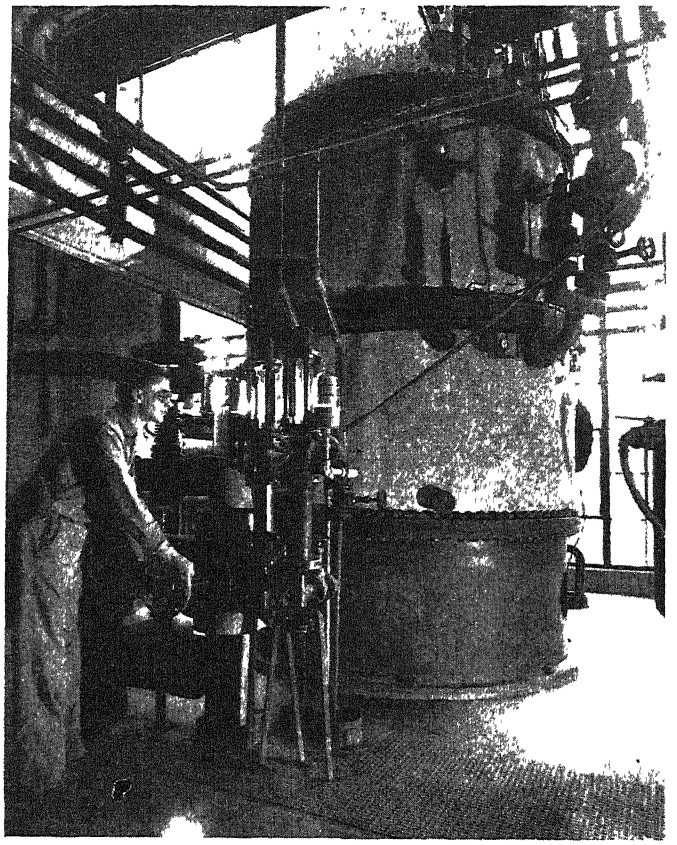
New Delhi

are also conveniently subdivided into a number of smaller groups, possessing the general characteristics of the large family but more closely related to other members of the smaller groups Thus, the glycols possess the chemical structure of dual alcohols, and glycerol similarly may be considered a triple alcohol since its molecules embody three characteristic alcohol groups

Most familiar of the glycol group of the alcohol family is ethylene glycol, widely used as an anti-freeze in the radiators of automobiles and now largely gone to war for similar service. Ethylene glycol is a somewhat syrupy liquid whose various properties are intermediate between those of ethyl alcohol on the one hand and glycerol on the other Consequently, its commercial uses somewhat straddle between those of its more familiar relatives However, its double alcohol nature allows it to enter a number of chemical reactions and to form derivatives of unique value. Thus, one or both of its alcohol groups can be converted into an ether group and the resulting compounds then possess important value as solvents. Or still other modifications can be made in its properties by combining one or both of its alcohol groups with an acid to form esters. The progressive modification of the chemical structure through these changes, effected singly or in various combinations, provides a series of derivatives in which particular characteristics are either emphasized or suppressed practically at will or wish.



In a styrene plant, where products derived from coal and petroleum gas are combined to produce an essential ingredient used in the manufacture of one type of synthetic rubber

WATER-SOLUBLE WAXES—From this glycol, synthesis also produces an especially interesting series of waxes which are unique in being waxy in the normal way but at the same time soluble in water, as no normal wax is. These interesting products are formed through chemical reaction of molecules of ethylene glycol with themselves. The two alcohol groups in each glycol molecule react with those in other molecules, with the result that the product consists of long chain-like molecules made up of many of the smaller original ones as links. The number of links can vary over a rather wide range and thus the properties of the product can be controlled to meet particular needs such as, for example, for a softer or harder wax. Under the trade-mark Carbowax, these water-soluble waxes are already performing important services in industry where their similarities to and differences from ordinary waxes make them particularly useful. They possess lubricating properties and hence can serve where solubility of the lubricant in water is important. Ordinary lubricants on textile machinery, for instance, occasionally stain goods in process, a trouble easily corrected if the lubricant can be washed out of the cloth with water. Wire drawing, molding of rubber and plastic articles, and other similar operations are benefitted by the use of this new family of lubricants

Recent approval of the use of the Carbowaxes in cosmetics and pharmaceuticals opens other fields for their unique properties. Cosmetic creams and lotions forming powder bases that can be washed off, and medicated ointments for external application, which need no special solvents for their removal after their purpose is served, are obviously valuable. That these compounds can be produced with varying properties gives them other advantages over the useful waxes of more or less fixed characteristics.

Ethylene glycol can be made to react with cellulose to yield a water soluble glycol-cellulose This product, marketed in limited quantities under the trade-mark Cellosize, possesses the film-forming properties of other cellulose derivatives but is easily dissolved in water. Furthermore, it strongly resists oils and oily solvents so that it can be applied from solution to protect surfaces—concrete, for example—from oil spilled on them. When the protection is no longer needed, simple washing removes the coating. Resistance to oil makes coatings of this material useful for lining paper containers for oily products. When moisture resistance is necessary, as it often is, Cellosize can be modified by the addition of appropriate amounts of glyoxal, the aldehyde derived from ethylene glycol, to make the finished film proof against any but prolonged soaking in water

Glyoxal itself gives chemists a new tool for use in synthesis. It is a dual aldehyde in the same way that glycol is a dual alcohol, and since it is a solid with low volatility and very little odor, it can serve in many of the applications of the familiar formaldehyde An example is its hardening action on casein in glues and paper coatings to which it imparts relative water resistance.

Recently attracting special attention is another glycol bearing the same relation to ethyl hexane that ethylene glycol bears to ethane. This compound —2 - ethylhexanediol - 1, 3, to give its proper chemical name—possesses the remarkable property of repelling insects of many varieties even though it is practically odorless itself The pervading odor of citronella and other insect repellants in summer is barely sufferable to many people who endure it only in preference to the greater annoyance of ubiquitous mosquitoes, gnats, and biting flies. The idea has been to create an odor so disagreeable to insects that they will keep their distance. The new compound does just that. Apparently its odor disturbs the insects but is too weak and tenuous to annoy their intended victims.

The compound can be readily incorporated into creams, lotions, and similar preparations and in these forms retains its repelling ability for many hours. Just now this repellant is at the fighting fronts, protecting our armed men from insects infesting the tropical environments in which they fight. Mosquito-borne malaria is the most serious of the hazards against which it is providing protection Its fighting garb includes a dual-purpose camouflage cream applied to the face and hands to hide the soldier from his human enemies and to protect him against the flying pestilence of mosquitoes.

These few compounds illustrate the versatility of our developing chemical industry of compounds derived from petroleum and natural gas and called aliphatics to distinguish them from the aromatic family originating in coal tar The chemical industry now produces a list of some 160 various compounds from these sources. Many of them were known before only as museum specimens or entries in the reports of scholarly researchers. Their industrial development extends back over a period of about 20 years and it is still going on. War demands have naturally stimulated their widened use and their larger scale production. When peace comes,

— these once unfamiliar compounds will become essential parts of new and important developments

GRAVITY OF PROBLEMS INCREASES— The relation of this phase of chemical industry to the present huge problems of synthetic rubber and aviation gasoline and to the future problem of diminishing petroleum supplies requires comment. These three problems are grave principally because of their magnitude. Synthetic rubber by the thousands of tons is the kind of operation which the chemical industry takes in its stride. By the hundreds of thousands of tons the problem is different. Similarly, aviation gasoline and motor fuel from either natural gas or coal become serious undertakings only when quantities needed suddenly soar to great heights

The technique of converting the gaseous constituents of natural gas, for example, to the liquid hydrocarbons needed for motor fuel involve no unfamiliar chemistry. Processes for the purpose are known and already have been practiced on small scales well in advance of urgent need. Yet when output must be suddenly magnified some thousand fold, the very size of the operation introduces new problems. The same is, of course, true of synthetic rubber processes, some of which were operated in this country more than a decade ago, and of coal hydrogenation, long subject of experiments here. Although the chemical elaboration of natural gas to products described above is by no means the same as that demanded to solve the problem of future motor fuel, yet familiarity with the fundamental chemistry of it gives assurance of the successful solution of the difficulty as it develops.

With so large a demand in prospect for our natural gas output to supply motor fuel, the question naturally arises as to where raw material for expansion of these lesser synthetic operations will be found. The answer lies in the relative magnitudes of the two Where motor fuel requirements reach above a hundred million tons annually, the need for chemical products of natural gas and petroleum are unlikely from present indications to be substantially greater than a similar number of pounds. Thus the problem of raw material supply for this latter purpose is scarcely subject for concern, at least for the present.

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SOIL STABILIZATION

Achieved Through Use of New Resin Compound

A CHEMICAL method of preventing mud by making soil waterproof has been proved in use on roads, airplane landing fields, and other construction projects here and abroad, according to the Hercules Powder Company.

Its proper use means an end to muddy streets and roads, and a time-saving aid in road construction work where mud may cause delays. Stabinol, as the chemical compound is called, can be used to stabilize unsurfaced dirt roads in rural areas where the traffic is light, or it can be mixed with soil that serves as the base on main highways with hard wearing surfaces.

By mixing Stabinol, a resin compound, with the top few inches of soil, a waterproof surface is obtained. The water will drain off or evaporate, rather than seep through the treated soil and turn it into mud. Stabinol-treated soil resists penetration of surface water, the chemical company says, and also the capillary rise of moisture from below

A truck can move over Stabinol-treated roads during or after a rainstorm without churning up mud or digging ruts in the road A car splashing through a puddle on this type of road will kick up dry dust, not mud, behind it.

Only fractional amounts of Stabinol are required, usually about 1 percent of the total soil to be treated, and the "stabilized" soil has the same appearance as the original dirt. Hercules says that Stabinol does not increase the load-bearing capacity of soil, but it will prevent the soil from getting wet and thereby losing its strength. This effect of soil stabilization will last for years; roads laid down more than five years ago, for example, are still waterproofed.

PILLBOXES

Made of Plastic, Unaffected by Dampness

PILLBOXES—literal boxes for pills, not strong points of defense—assume special importance in this global war Each soldier carries sulfa pills with him at all times and these must be carefully protected until they are needed With armies operating in the jungles of the Pacific islands and the Far East, metal boxes are less than perfect Latest development in this phase of the war is a pill box of transparent plastic which is unaffected by dampness and which permits its contents to be inspected at any time without opening or breaking the seal.

UBIQUITOUS CHEMICAL

Used in Perfumes, Insect Repellants, and Protective Coatings

PHTHALIC anhydride, produced now in large quantities by the catalytic oxidation of naphthalene, was once used principally as an intermediate product in the preparation of certain useful dyes. But, like many chemical products, its applications proliferated. A valuable perfume fixative capable of increasing the life of fine perfumes was derived from this intermediate. The compound, diethyl phthalate, was also valuable as a denaturant for alcohol to be employed in perfumes, and as a softening or plasticizing agent in nitrocellulose plastics. An important family of resins, particularly useful in modern paints and protective coatings, next came from phthalic anhydride and achieved such wide acceptance that this material has had to go under strict allocation in the present war production program.

The latest phase of phthalic anhydride's usefulness, however, threatens to overshadow, at least for the present, all the others. Diethyl phthalate, compound of phthalic anhydride and ethyl alcohol, has proved to be valuable in repelling the voracious malaria-bearing mosquitoes of the South Pacific. Practically odorless to the human nose, this compound turns out to be highly objectionable to insects. The combined demand for phthalic anhydride has forced further tightening of restrictions on its use. None is now available for civilian use.

WHITER PAPER

Promised by New Bleaching Process

SODIUM peroxide is the bleaching agent used in a new method of whitening mechanical paper pulp recently announced by engineers of E. I du Pont de Nemours and Company By using 1.5 to 2 percent of sodium peroxide in a new process of bleaching, groundwood pulp can be economically brightened as much as 7 to 11 points on the brightness scale used in the industry to compare papers The characteristics of the pulp treated by the new method are reported to be far superior to those made by present practices. Principal application of mechanical pulp is in newsprint where its short life and lack of whiteness are less important than its cheapness. The new bleaching process is expected to widen its usefulness into other fields in addition to improving newsprint. War restrictions on production of sodium peroxide indicate that the new process will have to await peace for complete development.

CLEAN GUN BARRELS

Assured by New Cartridge Primer

GUN-BARREL cleaning, one of the bugaboos of soldiering, has been reduced to a minimum for United States troops through the use of a new type noncorrosive carbine cartridge that leaves no damaging deposit in the barrel when it is fired.

The deposit left in the barrel of a rifle by the primer after older cartridges had been fired, produced rust and made frequent cleaning necessary. Instead of leaving a rust-accelerating deposit, the new primer developed by Winchester for the 30-caliber carbine, leaves a protective deposit in the bore, and thus relieves the soldier from constant cleaning.

In order to take care of deposits due to elements other than the primer, the carbine is equipped with a cleaning apparatus, the use of which is required only once a day. The new cartridge is a 30-caliber pistol type, the bullet of which has a muzzle velocity of 2000 feet per second. Its effective range is 300 yards, which is four times that of a .45-caliber automatic pistol cartridge.

Lead Carries Its Weight

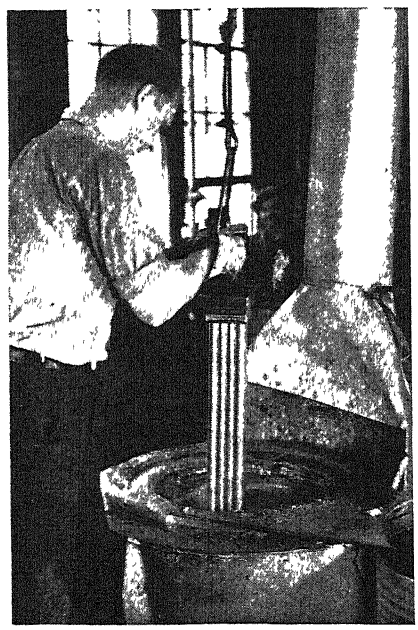
No One Surveying the Potentialities in New Alloys and Steels should Forget Those Old Standbys, Like Lead, That Have Entered New Fields and Permanently Improved Their Application-Positions Generally. Here Are Some of Lead's Recent Advances and a Hint of its Post-War Prospects

LEAD, distinctive for being the heaviest common metal and for having the lowest price per pound of all nonferrous metals, is also one of our most versatile industrial materials. Its list of applications, long as it was before the war, has in the last few years been extended—with the help of research, of new coatings and alloys, and of shortages of more critical materials—to include many new uses that are self-sustaining and hence of major interest to those who ponder the products of peace.

Among the more significant of these are certain applications that depend on the *weight* of lead for their existence. At the present time about 10 percent of the current consumption of lead is primarily utilized because of its weight Thirty percent of the metal's consumption is the result of its softness, workability, and corrosion resistance, and 24 percent because of such properties of its alloys as low-melting points or good bearing qualities or favorable shrinkage properties. The applications of lead's chemical compounds are responsible for 33 percent of the metal's consumption.

IN BULLETS—Lead is 11.34 times as heavy as water, or half again as heavy as iron and 6.5 times the weight of magnesium. The best known application of this quality is its use for bullet cores. Lead's melting point is about 620 degrees, Fahrenheit, and some of its alloys are completely molten at 350 degrees, Fahrenheit, thus establishing their utility for solders, type metal, fusible alloys, short-run molds and dies, and so on.

Lead and certain of its strong alloys with antimony or calcium that have just the right electrochemical properties are also virtually completely resistant to attack by sulfuric acid and corrosive sulfates, hence are employed for storage batteries; its resistance to sulfuric acid alone brings the metal into use for chemical plant equipment—pickling tanks and the like. In addition, lead's general corrosion resistance is partly or entirely responsible for a host of such uses as roofing and flashing, plumbing items, cable sheaths, pole-line hardware, containers, and so on.



Removing a steel pattern from the molten lead bath used in the manufacture of molds for casting plastics. The lead is later reclaimed

Its ductility permits it to be extruded into long, heavy tubes for cable sheathing and pipe, or into tubing for toothpaste tubes, and to be rolled into heavy sheet for tank linings and sulfuric acid chambers, or into thin sections for wrapping-foil. Its special property of resisting the passage through it of X-rays and radium emanation make it useful for lining the walls of X-ray rooms or cabinets.

Among the chemical compounds of lead having greatest importance are white lead carbonate and sulfate, used in high-grade white paints; litharge and red lead, its oxides that are employed in storage batteries, paints, insecticides, enamelware, oil-refining, synthetic rubber, for examples; tetraethyl lead, used in high-test gasoline; and so on.

In one pre-war year (the following figures are for 1939) the order of annual lead consumption by various products, exclusive of the uses of lead chemicals, was something like this: storage batteries took 198,000 tons; cable sheaths 74,400; buildings (roofing, pipe, and so on) 50,000; ammunition 42,300; foil 21,800; solder 20,000; calking 16,000; type metals 14,000; bearings 12,800; automobiles 8900; non-ferrous castings 7500; lead-alloy coated steel sheet 6000; and other uses 63,100.

The picture since then has changed significantly. Storage batteries still head the list as the chief outlet but ammunition has moved up to second position, with lead-coated steel, bearings, and solders responsible for much higher tonnages of lead consumption than formerly. Some items—collapsible tubes, for example—appear on the list of major applications for the first time. In addition, two or three other wartime developments in the use of lead, not yet out of the "minor" classification, bid fair eventually to rank among the important uses of that metal.

MOST AVAILABLE METAL—Lead's present position must be studied against a background of the war's effect, for it has been the "most available" metal during most of the war period to date, and thus has been widely used to replace other metals wherever possible. Many of these applications were simply a more extensive use of lead in ways in which it had always competed on its own merits—plumbing pipe, flashings, and shower pans; flashing on buildings; lead-base bearing alloys; die castings; industrial pipe and tank linings; gaskets; and so on

Other replacements are new uses for lead. Lead alloy nameplates, hard lead drum trap covers and rings, water-closet floor flanges, have been developed to take the place of brass. Lead alloy couplings are employed to save copper and bronze on certain kinds of cement-asbestos pipe. Lead foil is being used as wrapping in a number of new fields such as the fast-growing dehydrated food industry. Evidently here to stay are some of the above and a few others such as lead molds for casting plastics, lead battery-connectors and lead foil insulation.

Lead's versatility has been a boon to the industry that produces it, for it brings the metal into markets that are prosperous at the same time that some other uses may be suffering depression

pangs. This same diversification, a direct result of lead's varied properties, has been an even greater asset to the nation's war effort.

Bullet cores, for example, make use of lead's weight and ease of fabrication. The lead is first extruded as rod, cut into short lengths, swaged to the approximate shape of the bullet core, and then pressed into the jacket. Pure lead and antimonial lead (containing up to 2.5 percent antimony) are employed.

Again, antimonial lead die castings form the bodies of practice bombs Lead counterweights are used in torpedo mechanisms and in anti-aircraft and other guns. It is increasingly applied to provide perfect weight balance in airplanes and gliders—an almost paradoxical application because its primary purpose is actually the reduction of excess weight in the mechanism for operating the ailerons and rudders!

Here's how this comes about: In modern aircraft design, flutter characteristics of movable surfaces are so important that balance weights are added to all ailerons, rudders, and elevators on pursuit planes The weight of the surface tending to cause rotation about the hinge line in one direction is thereby resisted by a heavier balance weight at a relatively shorter distance from the hinge. Lead can be molded to the shape of the nose section so that its center of mass is at a maximum distance from the hinge line, and thus a smaller amount of balance metal has to be used than if a less malleable or ductile material were employed. One company alone has already consumed more than 200 tons of lead for just this one application.

IN PACKAGING—Another application where weight is at least no barrier to success is the use of lead foil for packaging in place of rigid containers of steel, tinplate, aluminum, cardboard, and so on. Although conservation of the materials formerly used was the prime mover in this development, the savings in weight, shipping space, and cost have been great enough to indicate that many types of lead-foil packages will continue to be used even when rigid containers are again available.

Heavy lead foils have long been used for packaging perishable materials, but such closures are expensive and easily damaged. The modern lead-foil package —essentially a bag made of foil-coated kraft paper—is substantial and economical while retaining the advantages of waterproofness and airtightness. These packages are being used as shipping and storage containers for rifles, machine parts, optical instruments, radio parts, powder, and detonators, in addition to the expected foods (the Army's famous K-rations, for example), drugs, bandages, cigarettes, and even matches.

The high density and atomic weight of lead also make it particularly useful in one field that is growing by leaps and bounds—the use of X-ray and radium for the internal inspection of castings, forgings, weldments, and finished industrial products. X-rays as well as the the gamma-rays of radium are injurious to persons inordinately exposed to them, so operators and "innocent bystanders" in industrial plants (where radiographic equipment may be in operation continuously, day and night) must be protected against the radiation.

Lead is the most efficient material that may be used economically to prevent the escape of X-rays from rooms or cabinets in which they are generated. A thickness of one millimeter of lead will completely absorb X-rays of the intensity developed by 75-kilovolt equipment and a 34-millimeter (1 1/3 inch) sheet is required to shield against 600-kilovolt X-rays

X-ray rooms are, therefore, completely lined with sheet lead. Doors are constructed so that their lead coverings overlap the lead covering on the jambs all around. Wall holes for electrical wiring must be lead-shielded and nails are often lead-headed to provide a continuous barrier. Even windows in such rooms are made of glass with a high lead content so that the operators may safely look into the closed room. A new development that should simplify the application of lead shielding is a lead-clad plywood, now available from stock in the standard plywood sizes.

Technologically, the outstanding wartime development for lead has been the evolution of new lead alloy coatings and the great expansion in use of lead-coated iron and steel sheet. Recent improvements in lead-coating processes have yielded hot-dipped lead coatings that compare satisfactorily with galvanized steel in durability (in some cases the lead coatings are *more* durable), and have the added advantage of being an excellent base for paint.

The lead coatings are ductile and can be bent and formed without flaking or cracking. Lead-coated sheets may also be die-formed, the lead coating actually serving to lubricate the dies. The Western Electric Company is now applying lead coatings to more than 60 percent of its pole-line hardware. Items varying from small washers to thin curved sections 8 feet long are being successfully coated along with large amounts of sheet for duct work, containers, and so on.

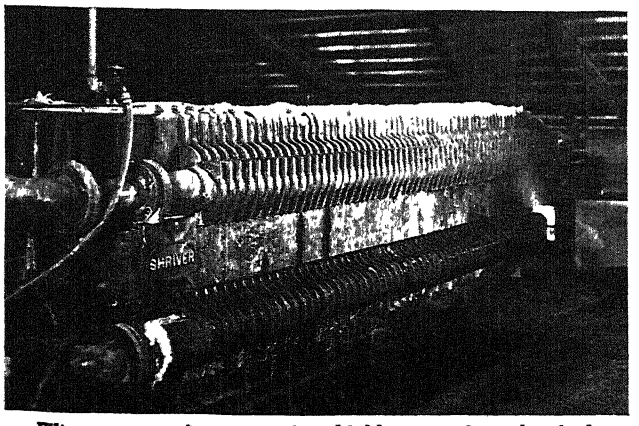
Another processing development of notable significance is the growth in use of lead "burning"— the welding of lead components directly to each other without the employment of another metal as in soldering or "wiping." Forced by the shortage of easy-working high-tin solders to learn lead-burning, many plumbers have found it a surprisingly convenient method of making lead joints (some plumbers have been strong proponents of lead burning for years) and one that "pays off" in any case. Many plumbing installations now use no solder and thus save $5 to $10 or 3 percent of the total cost in a typical bathroom.

Lead has recently been found to be an excellent mold material for casting certain thermosetting plastics. It is sensitive enough to receive the smallest and most delicate impressions from the pattern. It is soft enough to be easily removed from the casting, yet sufficiently strong enough to retain its shape during the pouring of the liquid plastic.

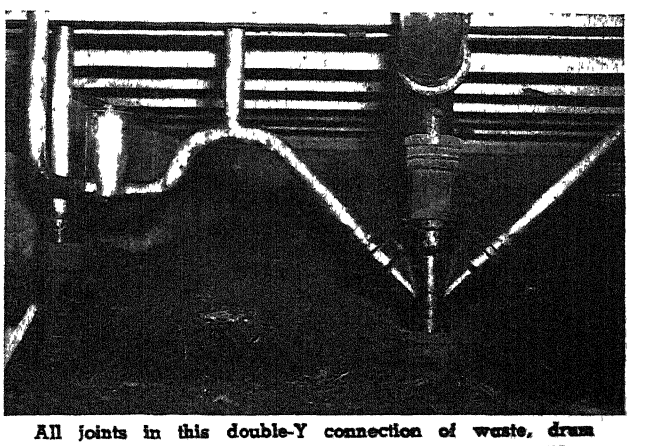
For straight-draw molds, for example, a steel pattern of the exact size and shape of the plastic article to be made is dipped into and quickly withdrawn from a bath of molten lead. The lead, chilled by the cold pattern, adheres to it as a thin sheath. The sheathed pattern is then cooled in water and the pattern is withdrawn, leaving a perfect lead mold, into which the liquid plastic is poured.

MOLDS RE-USED—The mold is later removed with an air-hammer and returned to the melting pot for re-use. This technique suggests that there may be many possible uses for lead in forms and molds that must be destroyed in removing them but which can be salvaged at negligible cost simply by remelting.

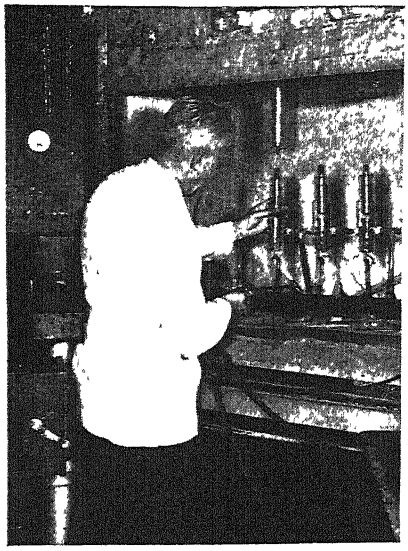
Typical of some of the new uses of



Filter presses for processing highly corrosive chemicals embody large amounts of lead in plates, frames, and so on



All joints in this double-Y connection of waste, drum trap, and lavatory waste were made by use of lead welding



During manufacture, X-ray tubes are tested in this cabinet, which is lead lined to protect the operator

lead that not only conserve a more critical material but provide better service performance is Electric Auto-Lite Company's steel re-inforced lead-alloy terminal for automobile batteries. The commonly-used metals strong enough to withstand the vibration of service are soon corroded by the battery fumes, with consequent impairment of the car's electrical performance. The new terminal is acid-proof, yet strong enough to be clamped immovably to the battery post. The manufacturer believes the new terminals have an exceptionally bright future.

In general, the lead industry is cheerful about the place of its chief product in post-war America. At the present time only 40 percent of lead consumption is supplied by primary domestic production—the rest is imported and made from secondary metal. This makes lead one of the few major metals (perhaps the only one) whose war-production capacity has not been expanded beyond the probable post-war requirements. Nor will lead scrap come back to plague the primary producers to the same extent as will the scrap of other metals.

In addition, it is expected that out of its expanded use as an alternate and substitute, lead must gain certainly some, probably many, permanent conquests. These will probably not include the high-lead solders, which are unpopular with the average worker and will be retained on anything like their present scale of use only in the canning industry. The high-lead bearings, on the other hand, have made an engineering hit and will continue in use, although they account for only a small amount of lead because of the thin films employed.

Expectations on foil are mixed. The new foil-coated paper package is believed to have a bright outlook, but the ordinary lead foil of commerce will meet some tough competition from other foils and wrappings. In the field of collapsible tubes, though, lead tubes may permanently replace a large proportion of the tin tubes formerly used.

And since automobiles, houses, and public utility lines—the respective outlets for lead in storage batteries, plumbing, and cable sheaths—will be produced in boom amounts to fill the war-starved demand, the future of lead in these products is obvious.

Yes—as a leading aluminum manufacturer once respectfully said of lead—"lead carries weight," and it will carry more than its share in the post-war industrial world.

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PREFABRICATED HOUSES

Will Use Both Metals and Non-Metals in Mass Production

THE PREFABRICATED (or better, processed-materials) house of the future will depend on non-metals as much as on metals for its mass-produced units, surface beauty, and requisite strength. This was predicted at a recent meeting of the design-materials group of the Architectural League of New York, held under the direction of Morris Sanders. Designers familiar with steels, non-ferrous metals, plywoods, plastics, and so on, discussed the possible applications of their specialties in post-war housing of this type.

Because of their cost, the non-ferrous metals are expected to find little application for the entire thicknesses of walls, but they are likely to serve in laminated forms as exterior surfaces over steel For example, thin copper or brass layers rolled onto steel sheets can be made on a mass production scale and would offer the strength of steel plus the surface beauty and strength of the copper or alloy at a nominal cost.

Similar composites involving plastics as veneers over steel will possibly be even more popular because of the variety of colors or surface effects that will be possible. Plastics "all-the-way-through," however, will scarcely be used, owing to the relatively high cost and inferior stiffness properties. The opportunities for plywoods, rolled out and bonded on a scale to match sheet metal manufacture, seem especially good.

Structural steel itself has been shown by long-time tests to be not seriously corroded in normal construction in non-industrial atmospheres. Thus steel, especially when used in conjunction with non-metallic or non-ferrous veneers, seems to have a bright future in this field.

FLUOROSCOPIC INSPECTION

Useful for "Pre-Selection" of Metal Castings

THE USE of fluoroscopy (visual examination of the internal nature of an object on a fluorescent screen) for industrial X-ray inspection has generally been confined in this country to the examination of auto tires, packaged goods, citrus fruits, and shoe fittings. At the present time, however, considerable research is underway to establish the best operating conditions for the fluoroscopic inspection of aluminum and magnesium aircraft castings.

The fluoroscopic method is most useful as a method of "pre-selecting" castings with relatively gross defects for subsequent radiographing. It is especially valuable for the inspection of cored passages in castings and as a tool for the general control of foundry practice. Properly applied, it can cut down in large measure the great amount of X-ray photographic work (radiography) now applied to light alloy products.

The suitability of a casting for this type of inspection is governed by its size and shape. Light alloy castings are suitable that have a maximum cross section of two inches in any portion and that are of such shape that manipulation will allow the X-rays to penetrate each part of the specimen and give a readable shadow on the fluorescent screen

ELECTROLYTIC MANGANESE

Has Interesting Properties; Uses Slow in Developing

MANGANESE, vital to the manufacture of virtually all types of steel, is now produced in this country in amounts exceeding 400,000 tons per year. Smelting processes are employed, and yield a mixture of manganese and iron plus other impurities known as ferro-manganese.

In recent years the Bureau of Mines has sponsored the development of a process and plant for the electrolytic manufacture from low-grade domestic ores of highly pure manganese metal, for the original purpose, it is believed, of relieving this country's dependence on foreign sources for much of its manganese ore. According to R. S. Dean of the Bureau, in a paper presented at a recent meeting of the American Institute of Mining and Metallurgical Engineers, electrolytic manganese production capacity in this country is now about 1800 tons per year.

New uses for this pure material have been slow in developing. At present its chief application is in the manufacture by the mints of the new nickel-free "nickels." It has also been used in magnesium bomb casings and has been sent to England under lend-lease for addition to aluminum alloys.

An interesting use for electrolytic manganese that may increase in importance is in an age-hardening alloy containing 60 percent copper, 20 percent manganese, and 20 percent nickel. Its properties (its tensile strength is 80,000 p.s.i. for soft material and 180,000 p.s.i. for hardened) and its fatigue strength are said to be superior to those of beryllium-copper.

Although its high price *has* restricted the applications of electrolytic manganese, as the Bureau avers, it is also true that, even if it could be sold at some figure near the price of the contained manganese in the regular ferro-alloy, its use in the major market (steel-making) would not significantly increase, for metallurgists can see little advantage in purity alone for steel-making purposes.

Safety Increases, But . . .

Statistics Show that, While Much Has Been Done to Reduce Industrial Accidents, There is Still a Long Way to Go. Codes and Standards Are Starting Points. Small Plants Must Be Brought Abreast of the Practices of the Large Ones if the Average is to be Brought Up

SOMETIME early this summer the National Safety Council will release its 1944 edition of "Accident Facts," a terse but lucid accounting of what has been done about keeping industrial workers from getting injured and killed on the home front. It will show that, as compared to World War I, and even to 1926, the industrial accident figures so far in World War II are highly encouraging—but by no means encouraging enough. Many of the figures will have gloomy implications, as, for example·

1) The accidental death toll of workers from getting injured and killed nearly three times the total for our armed forces. From Pearl Harbor until January 1, 1944, 32,078 soldiers, sailors, and marines died as war casualties; 94,000 workers were killed in accidents.

2) The number of workers injured will dwarf the total of war wounded. 45,595 of our armed men were wounded up to January 1, 1944, while 8,800,000 workers were injured (The report, when issued, may use even later figures)

3) Accidents will cause each 1000 industrial workers to spend an average of 150 to 200 days away from work per year. Time lost without the hurt men leaving their jobs will add another 600 to 700 days. In short, the entire war effort will lose, each year, more than a full week of production because of industrial accidents. And this time loss will be multiplied many times over by the "indirect costs of accidents"—the time lost by men who leave their machines to help the injured one, the slowings down by workers who suffer shock at seeing someone else get hurt or who fear that hard effort may cause them to get hurt, the absenteeism and the labor turnover caused by workers disliking to work in a place where they have seen a distressing accident.

4) Frequency of accidents, as measured by number of injuries per million man-hours worked, probably will go down a little in 1943 figures.

5) Severity of accidents, as measured by the number of days lost per 1000 man-hours, probably will go up somewhat in 1943 figures—this is one of the paradoxes which all safety engineers are studying, pondering, and attacking.

Distressing as these figures are, they are not nearly so bad as they might be. The fact is, half again as many workers were injured per million man hours worked in World War I, and the increase in the accident rate as new workers were trained in that war was much higher than in this one. Direct comparisons of figures are not too practical—statistics were not so complete then as they are now, and many kinds of dangerous chemical, metal working, and other industries exist now that had not yet been born then. Nevertheless, it is certain that factory hazards have been cut by one third, and in some big plants (steel mills are an example) they have been cut five sixths.

Courtesy Carnegie-Illinois Steel Corp.
Sandblasters are completely armored

Statistics are fairly clear from the mid '20s on, and the National Safety Council uses 1926 as the 100 percent or "yardstick" year. Some of the measurements are startling.

Frequency of accidents, per million man-hours worked, went down more than 60 percent between 1926 and 1932. The trouble is, it has remained on a fairly constant level since then, going up and down a trifle from year to year and being about 68 percent below 1926 right now, but not going on down.

Safety men are happy about this, but not overjoyed. They point out that every school child begins getting the kind of training which will cut down accident frequency rate while he is in kindergarten, and that "don't get hurt" psychology is dinned into him in his church, when he learns to drive his car, during his military training—in fact, everywhere he turns. It is probable that more agencies have concentrated on getting Mr. U. S. Citizen to avoid the practices which cause little accidents than have influenced any other phase of his life. Much as the industrial safety engineers have done —and they have done plenty—to reduce the accident frequency rate, that rate is as low as it is because the whole nation has been working on it.

The severity rate is a different matter. It did not go down nearly so fast as the frequency rate and it never has gone down so far. But the decline has been steady. Almost every year finds it lower than the year before, and it is now down over 50 percent from 1926 Here the trouble is that most of the decline has been in the minor degrees of injury. Deaths have gone down only some 40 percent, permanent partial disabilities only 25 percent, or less than half the total severity rate decline. And this, of course, is one of the major safety problems.

METHOD OF ATTACK—Safety engineers know that no drastic reductions in industrial accident rates, such as were possible when guards first were applied to machines and equipment, are in sight right now. Much of the safety progress of the immediate future will be made by correcting a host of minor deficiencies, the results of which can add up to very large gains over a long period of time. The safety battle has become a war of attrition, the results of which can be aided by accurately recorded statistics.

First step is the simplified report. Accident reports, unfortunately, must be long and complex, for the employer and his insurance company depend upon them to defend themselves in law suits. But every pages-long report can be reduced to a simple sentence. Examples: "The man put his bare forefinger into a hole in an attempt to extract a broken drill, and received a deep cut." "Lumber was piled improperly; a board slid off the top of the pile and struck the man in the abdomen." "The woman neglected to wear her safety goggles and was struck in

Courtesy Willys-Overland Motors, Inc

The girl on the left has a good all-purpose suit for light work but would be better off with safety shoes. The girl on the right is inviting trouble in many respects

the eye by a steel chip." And so on.

Such sentences are easy to tabulate by common causes and severities of accidents. The tabulations are used in the factories compiling them, of course But even more important, such figures can be forwarded to the National Safety Council and to the American Standards Association for industry-wide action.

Entire industries get together with the American Standards Association, apply the collected data, add the personal viewpoints and experiences of safety engineers, and work out safety codes. Right now the American Society of Bakery Engineers is working with ASA on a safety code for that industry. (Food industries in general are slightly higher in frequency rate of accidents than the average of all industry, but are lower in severity rate.) Standard safety codes have been worked out recently for hoists and cranes and jacks—heavy materials handling is one of the worst sinners, accounting for about one fourth of all compensated injuries and one fifth of all permanent injuries. Gas hazards are bad in industry; a proposed ASA code will hold the maximum concentration of oxides of nitrogen (found at welding and other operations) to 25 parts per million as compared to the 39 parts per million which has been in common use since 1913.

CODES ARE STARTING POINTS—State labor departments use these codes, add figures from the reports of their inspectors, consult the researches made by the United States Bureau of Mines, the National Bureau of Standards, and other agencies, and from them work out laws which their legislators enact. It is a rare factory, however, which does not go beyond the demands of the law in working out its own safety practices. All the codes possible to compile cannot be more than starting points for the development of real safety programs.

The effect of a code is to list the hazards common to any factory, department, or occupation, and the minimum protections permissible for overcoming them. From that point on, safety engineers of individual factories list the hazards applicable to their own conditions, and take steps to reduce them.

Slippery floors are given abrasive coatings or admixtures in the concrete, or provided with surfaces which will make footing safe. Hot or otherwise dangerous objects are painted distinctive colors—the American Standards Association has a code for this and the Du Pont company has developed a safety color system which was described on page 224 of the May, 1944, issue of Scientific American. Light is thrown into dark corners. Special safety clothing is provided—the advance in the design and use of safety clothing shares with machine guards the principal credit for the advance in industrial safety of this war as compared with the last one. Special hazards are studied; the presence of an electrical hazard, for example, outlaws some types of steel-capped safety shoes which are acceptable for other hazards.

Areas of the body most likely to get hurt are studied. Generally speaking, fingers receive 22 percent of injuries, the remainder of the hands only 8 percent. Trunks receive 20 percent (protective armor for the abdomen is hard to design), and the legs, which also are hard to protect, 13 percent. Toes are so well guarded by safety shoes that they receive only 4 percent in spite of the likelihood of heavy objects falling upon them and workers stepping into dangerous places. Eye injuries are down to 4 percent; they could be nearly eliminated if safety practices regarding goggles and face masks were followed.

The slightness of the increase in accident rate with the hiring of so many thousands of untrained workers is due to training programs as well as to machine guards and protective equipment. Untrained workers do have higher frequency rates of accidents, of course; this is demonstrated by the fact that the newly industrialized far west has a higher rate than the older industrial regions of the east. "Lack of knowledge or skill" is blamed for 30 percent to 50 percent of all accidents due to personal causes But safety training is intensive. Bethlehem Steel Company even goes so far as to have a Gas Mask Training School in which students are treated like combat troops—they work under actual smoke-discomfort conditions against which their masks alone can protect them, while instructors watch through glass panels and tell them what to do.

Training courses seek to keep employees safety-minded "around the clock." One good reason for this is that a man is not likely to change his mental habits just by entering the factory door; if he is dangerous in his practices at home he will be dangerous at work. Another is that accidents occurring off the job cause from 20 to 40 percent more lost time than the "on the job" ones. Western Electric encourages employees to buy and own their own safety clothing and safety type tools, publishes stories in its house magazine of employees who have been saved from being hurt by wearing safety shoes while working in their garages or by using life lines while painting their houses. Pullman Standard, in its "no compromise with safety at any time" program, requires plant visitors to wear goggles and other protections while walking through its shops.

Studies are made of special types of employees. National figures show, for example, that the old and well trained employee is far less likely to have small accidents—his frequency rate is low. The trouble is that when he does have an accident it is a bad one. His comparative severity rate is high. Handicapped workers are in a similar group; only 2 percent of accidents due to personal causes are attributed to body defects and handicapped workers are among the safest in the plant in the frequency of accidents, but their severity rate is high.

The old bugaboo of the "accident prone" person, who was believed to have caused most of the trouble, has been laid by such studies. Figures prove that the man who has had one disabling accident is the one least likely to have another. A survey reported in *American Machinist* showed that of 4404 previously injured men only eight had bad second accidents in 13 years.

WOMEN'S RECORD GOOD—Women have been the subject of special studies of industrial accidents So far their record is unusually good. Much of this can be credited to special precautions —many companies have redesigned their machine guards for greater safety for women. Use of more hoists where weights must be lifted for women has helped too—heavy weight lifting probably is the Number One cause of injuries, especially among inexperienced personnel. Still, safety men argue, "what is sauce for the goose"—the practices developed for women may be used to cut down accidents among men workers too.

Safety practices are easy to apply in a plant having 2000 employees or more, since the volume of business is large enough to carry the overhead charges of a full-fledged safety department. But the case of a plant employing less than 100 is different. And it is

A light chipping operation requires protection for face, hands, and trunk

in these smaller plants, which make up more than 90 percent of all factories, that the hardest drive of the next year may be made.

National Safety Council surveys indicate that the accident rates in smaller plants are nearly 50 percent higher than in large ones of the same industries.

Many small plants, of course, have safety records which are the envy of some of the big ones. Special observation shows that luck plays very little part in this superiority. These small plants have appointed safety executives ranging from foremen to superintendents, although, strange to say, treasurers and paymasters make good ones too; the principal requirements of a small-plant safety manager are that he have authority and that he be safety minded and willing to learn. They are using the same methods as the large ones.

Right now the smaller plant gets most of its safety education from industrial journal advertisers of safety equipment and from the salesmen of safety products. State inspectors, local safety committees, insurance company inspectors, and others who have a professional stake in safety, carry the rest of the informative burden.

The forthcoming drive will feature safety posters, simple report forms, and the profits in uninterrupted production which safety can pay. Safety for the small plant will be made simple And if there is any abrupt and drastic reduction in industrial accident rates, it may easily come from the combined drive of the safety equipment sellers and of all other agencies on these smaller plants. Safety in the larger plants and in the average of all industry will continue to grow, the pressure behind it will continue to increase, but the smaller plants must be brought abreast of the practices of the big ones.

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FLAME CLEANING

Has Advantages of Speed and Thoroughness

EXTREMELY rapid heating of surfaces of metals, followed by rapid cooling, for the purpose of removing scale, rust, and other surface coating, is coming into ever widening use. In some cases, as with removal of material from carburized surfaces, it is undesirable to heat the metal itself any more than necessary. Therefore an acetylene flame is used, being applied to very small areas at one time and quickly withdrawn; the soil has a tendency to lose its bond to the metal and to chip and flake away.

Some encrustations have different chemical combinations on their outer and inner surfaces. These will act like bi-metals when heat is applied—either their outer surfaces will expand more than their inner ones, or vice versa, resulting in a buckling and blistering action which breaks them loose. For these a wide flame generally is applied; the wider the area of heat application, the greater the effect of surface differences in thermal coefficients and the more effective the process.

On some alloy steels the pickling process used to take hours and was not always successful. Flame alone will not descale these steels. But when the action of the flame has loosened the scale, turned it into chips and raised the chip edges so the pickling liquor can get beneath them, the pickling process is rapid and clean.

Flame cleaning was known before this war began. It received its impetus when a war-born shortage of pickling materials made resort to other cleaning methods necessary. And improved flame cleaning is one of the techniques which definitely will survive the war.

MORE STAINLESS

Will Be Used as a Result of Increased Workability

PRODUCTION men in the plants of automobile, aircraft, household refrigerator, and other mass-production item makers are excited over the prospect that stainless steel may soon be far more workable in press dies than ever before.

Refusal to flow under the dies has been one of the principal handicaps of stainless Even so, the use of this metal has grown from some 34,000 tons per year in the 1920's to about 400,000 tons per year now. Nearly three quarters of this growth was during the peace years—stainless is not a war baby.

Product engineers like stainless for its high strength and its resistance to abrasion as well as its non-corroding qualities. Stainless probably has more strength-for-weight than any other metal in common use If the cost of fabricating it had not been so high, nobody knows how great its production might have become in pre-war years.

The exact degree to which flow-ability has been added is a military secret Engineers talk more about the degree to which this quality is expected than about actual accomplishments; the necessary steel-making knowledge still is in the laboratory stage Final results probably will need more power in the presses than the pre-war ones had, greater strength in the dies. But the war has taught production men how to get these things.

WORN GAGE BLOCKS

Can be Salvaged To Advantage

IN TIME, gage blocks become worn so that two or more surfaces are no longer accurate to the millionth-inch limits to which these blocks are made. Worn surfaces may be roughened, concave, convex, or out of parallel with each other.

Such blocks may be lapped so that they are true again, but then will be off size. With blocks as inexpensive as they are today, it generally is preferable to buy new ones to replace worn ones.

The worn blocks have many uses, however. In one shop, holes are drilled through them and they are used for testing depth gages. In another, the worn block surfaces are ground to contours which are used for checking accuracy of pieces which are to be form ground, such blocks then are excellent for checking the settings and the wear of dial gages which are to follow such contours either when mounted on the grinding and lapping machines or in the inspection department. But most often the worn blocks are refinished to the exact setting of a gage which must be correct within 00001 or even only .0001 inch, and are assigned permanently to that gage.

INDUSTRIOUS JEEPS

Are Already Doing Jobs in Industry

THE jeep, which performs more than 50 separate tasks on the battlefield, is finding its place in industry. Emergency transportation in the mile-long war plants is one of them. The jeep takes engineers, emergency maintenance crews, badly wanted supplies, and winds its way in and out of production lines, getting almost anywhere at higher speeds than are practical for most vehicles

Ability to get through mud too can be useful to industrial operations, and the jeep can go where even a horse will bog down. When a pipe line must be followed across the fields to where a leak is to be repaired, or a high-tension power transmission line is down and must be restored to service, the jeep can make hours of difference in getting the men and tools there and getting the job done.

Very few jeeps are available to industry right now—the armed forces want all they can get. Only the most important war plants are allowed to have any. But engineers looking ahead see many post-war uses for this car in big factories, in lumber camps, and for mining operations.

FELT FOR INSULATION

Is Dampening Vibration in Industrial Tools

WOOL felt, perhaps the oldest form of textile known to man, is rapidly becoming one of the newest of industrial materials.

Reason for the rapid development of new uses was the plentitude of this material. While other materials were held back because of shortage of supply, wool felt was tried as an emergency substitute for one purpose after another. Felt was mixed with synthetic fibers, processed by new methods, given all sorts of impregnations.

To the old industrial uses as a lubricant-sealing material for bearings and as a temperature insulator, employment as a vibration absorber was added. This proved important. Felt is now used as the basis of super-fine polishing wheels and even grinding wheels; it will absorb the shock of applying the wheel to the work and will dampen the billions of tiny shocks which occur when grits cut into steel.

Electronic Aviation

Military Developments Hold Definite Promise for Peace-Time Applications in Both Commercial and Private Flight. Radar Principles can Give Birth to Systems that Will Warn of Possible Collisions, Provide Block-Signal Control, and in Other Ways Promote Safety in the Air

By VIN ZELUFF
Assistant Editor, *Electronics*

MILITARY communiques, stories, and rumors covering accomplishments of electronic equipment on military bombers, fighters, and transport aircraft have naturally initiated serious thinking about peace-time possibilities of these electronic developments. Most post-war thinking recently has been directed toward commercial utilization of radio directing and ranging equipment, but easing of secrecy restrictions on electronic autopilots and engine controls now permits discussion of these topics too.

Autopilots in general have been used for more than ten years on commercial airliners, particularly on runs between New York and Chicago. The modern electronic autopilot, however, is a military development with extensive peace-time possibilities. Designed primarily for precision bombing, it holds bombers on an exact course determined by the bombardier. During the 15 or 20 seconds of the bombing run, the mechanism provides the stable platform which is essential if bombs are to be dropped accurately from high altitudes. During these few seconds, the plane must not deviate from its set course by a single degree. At 25,000 feet an error of one mil means that the bomb will miss the target by 360 feet.

The electronic autopilot system, as developed by Minneapolis-Honeywell Regulator Company, is built around a gyroscope with its case fixed to the plane and the spinning rotor free to move in all directions. When the plane dives, climbs, or banks, it moves the gyroscope case with it, but the rotor remains fixed with relation to the ground. This movement about the rotor is translated by electrical means into control of the operation of the plane's rudder, elevators, and ailerons, to return the plane to straight and level flight.

AUTOMATIC EYES—In this respect, the autopilot works automatically in much the same manner as a human pilot in maintaining straight and level flight. The gyroscope of the autopilot system

Spinning gyroscope unit of an electronic automatic pilot being tested on a tilt table at a plant of Minneapolis-Honeywell Regulator Company

operates as do the eyes of the human pilot to detect flight deviations and to signal the vacuum-tube amplifier in the electronic "brain" of the autopilot.

This amplifier, in turn, controls the operation of the servo units that manipulate the controls of the plane, just as the brain of the human pilot commands his muscles to correct flight deviations. In the case of the human pilot, his susceptibility to fatigue, his "reaction time," and his inability to detect slight variations the instant they occur, as well as errors in judgement and muscle coordination, limit the degree of precision of which he is capable.

The autopilot suffers none of these human failings. It detects flight deviations the instant they occur and instantaneously operates the proper plane controls to correct the deviations. Such automatic correction neither over-controls nor under-controls the plane, but keeps it flying straight and level with all three control surfaces operating in full coordination.

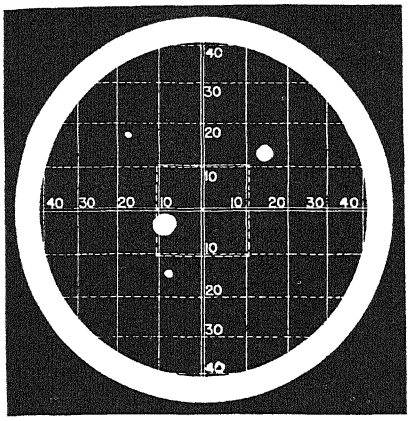
Another of the promising electronic devices now installed on multi-engine bombers and transport planes is the turbo-supercharger, a turbine-driven air compressor. This is used to boost the air pressure at the carburetor inlet to secure greater power output and better performance of aircraft engines at high altitudes.

In operation, air at atmospheric pressure is brought into the supercharger air intake and its pressure is increased by an impeller or turbo-compressor that is driven at high speed by engine exhaust gases directed on a turbine wheel. The air passes from the turbo to the intake of the carburetor, after losing some of its heat of compression to an intercooler. The higher up the plane is, the thinner is the air and the faster must the turbo-supercharger operate to maintain constant air pressure at the carburetor inlet as required for constant power.

PILOTS CAN CONCENTRATE—Since there are many variables that enter into the operation of the supercharger, an electronic control is used to adjust turbo-supercharger speed automatically whenever the plane changes altitude. This allows the pilot to concentrate on essential flying controls, whereas formerly he had to readjust engine controls continuously during changes in altitude. This electronic control is actuated principally by a pressure-sensitive element on the intake manifold and a governor on the turbo-supercharger. The control also limits manifold pressures and turbo speed to safe values, and anticipates pressure increases from turbo acceleration to prevent over-shooting of manifold pressures.

In response to signals from the control units on the engine assembly, the electronic amplifier furnishes power to a reversible motor geared to the waste gate in the exhaust manifold. This gate changes turbo-supercharger speed by allowing more or less exhaust gas to escape without going through the turbo.

Although there is a widespread opinion that radar devices will greatly



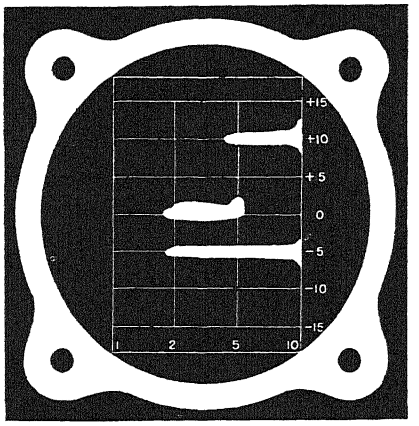
Indicator proposed by CAA for showing horizontal separation between planes in flight. Dots show relative positions of near-by planes; dot size roughly indicates their distance

change the aviation picture in the immediate post-war period, the peacetime applications of this highly secret system will be based on an entirely different situation. For military use, radar equipment detects the presence of objects which will not "co-operate," and this requires complicated and expensive apparatus. Peace-time aircraft, on the other hand, will "reveal" their presence to radar apparatus, so a different technique involving less expensive and less complex apparatus will be used.

Scheduled commercial air service must operate regularly and this means flying in practically all conditions of weather. To permit this, several electronic devices for installation in aircraft and airports have been suggested by Glen A. Gilbert, Chief of the Air Traffic Control Division of the Civil Aeronautics Authority, who recently stated that plans of the CAA for post-war air control are now ready and can result in a four-time increase in capacity of the present traffic control system.

One of the devices that will result from peace-time application of electronic war equipment is a collision warning device which will indicate the relative positions of other planes in the vicinity. Thus, each pilot flying in instrument-weather conditions will be able to avoid collision with other aircraft by observing the screen of a cathode-ray tube on which the location of other planes in respect to his own will be shown. Development by the CAA of this electronic indicator, called a vertical separation indicator, was halted by the outbreak of war.

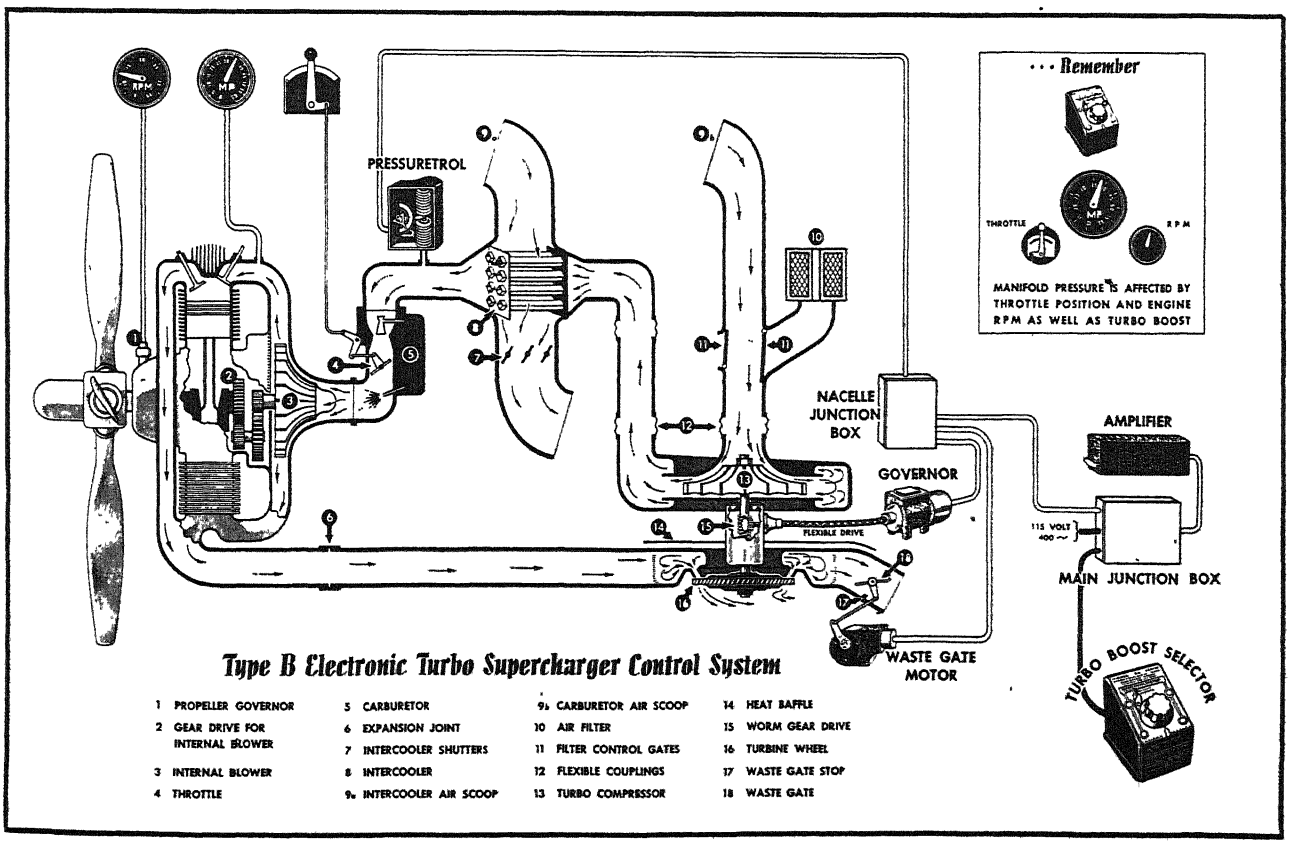
At the present time, aircraft report to control towers on landing fields enroute so that their path may be checked at fields along the route. This communication is carried on at present by means of voice signals over the radiotelephone equipment and forms a major limitation of the present air-traffic control system. The development of an automatic aircraft position reporter would materially reduce this limitation. Such a device would permit an aircraft to actuate a reporting mechanism as it passes each "fix" along the airways, in the manner that a train trips signals as it passes predetermined points along its route. The system would make use of a vertical pattern transmitter at each fix and a receiver in each plane to indicate the entry of the plane into the pattern. At the same time, a radio transmitter in the plane would be controlled by the



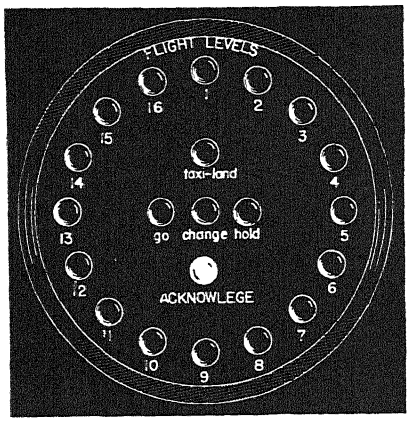
With a vertical separation indicator a pilot would be able to determine the vertical distance between his own plane (on the zero line) and planes above and below, even when flying in clouds or at night. Length of forms corresponding to other planes would be proportional to horizontal distances

fix-pattern receiver and a receiver at the fix point on the ground would receive the automatic report signals and relay them to an airway traffic control center.

VOICE SIGNALS ELIMINATED—Automatic posting equipment at the control center would be fed the position reports and would post them on a large panel, in much the same manner that stock quotations are posted on electrical posting boards. Such automatic posting of positions of planes and automatic transmission of traffic-control instructions from the ground would eliminate voice signals in the control of air traffic.



Complete electronic control system for a turbo-supercharged aircraft engine. See text.



The traffic clearance indicator envisioned by CAA technicians might take this form, with lights to indicate flight levels and central indicators to authorize movement of the plane aloft or on the ground

Reception of automatic control instructions in each plane can be accomplished by a traffic clearance indicator. This would consist of a dial containing a series of small lamps, one for each flight level. After clearance for a specified flight level has been received, the lamp for that level remains lit. Reception of clearance to another altitude would cause another lamp, designating another altitude, to flash and attract the pilot's attention to the fact that new orders had been received. He would then press a button, automatically transmitting a signal to acknowledge receipt of the clearance order and his plane identification. These signals would register on the control board on the ground, which would automatically register any disagreement if an error should occur.

Other indicator lamps on the pilot's panel would indicate special instructions when the plane is on the ground and would direct taxiing and take-offs Eventually, the traffic clearance indicator and the automatic aircraft position reporter may be combined into an automatic system similar to the block signal system used by railroads in this country. Such a system would contain marker stations that would transmit a signal that would act as a screen across each airway. These transmitters would be located at block-signal fixes perhaps 10 to 15 miles apart. Each plane proceeding along the airway would set up a "hold" signal for following planes on the same level. This hold signal would not be cancelled until the first plane had moved into the next block on the route or climbed or descended into another level. This would prevent two planes from being in the same block at one time on the same altitude level.

A constant picture of the actual position of planes within several miles of an airport can be made available to the ground control operators by means of electronic scanning screens. Each plane would be represented by a moving spot of light on a fluorescent screen. As the plane changed position, the spot would move to correspond and indicate the aircraft's horizontal position. A second screen would show the vertical relationship of the aircraft to one another

In the predicted 500,000 aircraft flying in 1950 will be many other new and old electronic applications ranging from radio communication systems, radio direction finders, and crew intercommunicators to electronic de-icing equipment, electronic gas gages for remote fuel tanks, electronic altimeters, and a variety of electronic controls, both for passenger comfort and flying requirements. The amount of electronic equipment per ship will naturally vary with the size and purpose of the ship, with commercial and military craft carrying far more vacuum-tube equipment than family flivvers CAA predictions of 10,000,000 passenger miles of scheduled passenger traffic and 600,000,000 tons of freight, express, and mail moved by air in 1950 point clearly to a promising future for individuals and manufacturers alike in electronic aviation.

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GYRO BALANCER

Uses Piezo-Electric Potentials and Cathode-Ray Tube

AN ELECTRONIC instrument, developed by Sonntag Scientific Corporation, for balancing gyro rotors, differs from conventional balancing machines in that it directly measures the alternating bearing forces exerted by the unbalance of the rotor, rather than tangible displacement of balancing parts.

The rotor to be balanced is mounted on rigid bearing supports and the entire assembly is seismically suspended on springs to eliminate the disturbing influence of floor vibrations. Alternating unbalance forces are transmitted by a practically rigid platform to quartz crystals, producing piezo-electric potentials which are magnified by vacuum-tube amplifiers and made visible on the screen of a cathode-ray oscilloscope.

The magnitude of the unbalance is indicated as a sine wave pattern, representing magnitude and location of unbalance. The cathode-ray screen is graduated horizontally into 360 degrees for reading the location of unbalance, and vertically into units representing the amount of unbalance.

ELECTRONIC HEATING

Demonstrates Multiple Industrial Uses

INFESTATION in grain is frequently troublesome. By application of electronic heating, wheat can be raised to a temperature of 135 degrees, Fahrenheit, to effectively destroy bacteria without harming the wheat. Insects can also be killed by this method, even though the infected products may already be in packages. The use of electronic heating for killing bacteria in fruit and vegetables canned in glass jars shows considerable promise.

Curing rubber and cooking and dehydration of dry goods are other applications which appear to be promising for electronic heating. Coffee has been roasted by this process but there are indications that the inside of the bean is heated more than the surface, with a resulting change in flavor. Feed corn has been heated, and table salt (if not too moist) has been heated and dried Paper cartons, rayon fiber, and shredded vegetables have also been dried satisfactorily by electronic means. In foundries, sand cores for molding have also been dried by dielectric heating

RADIO RANGE ALARM

Provides Automatic Safety For Airplanes

A NEW automatic radio-range monitor for use at airports provides instant warning if any radio course shifts as little as 3 degrees from its normal setting or fades below its normal strength, and also provides a check on the operation of airway fan markers located near the airport.

Four receivers are required for the radio-range monitor, one on each of the four radio courses of the standard CAA four-course radio range. So long as the radio course does not shift, the monitor receiver continuously picks up the interlocking "A" and "N" signals transmitted by the range station. If the course shifts, either the "A" or the "N" signals begins to predominate. When this happens, the monitor receiver automatically transmits an electrical impulse to the monitor board at the airport, which flashes a red light and sounds a siren to warn the ground crew; at the same time, the monitor automatically dials the range transmitter, which begins to send out to all pilots a warning signal at the end of each cycle.

The fan-marker monitor receiver is located near the marker, and is connected through a telephone line with a monitor board in the airport control room. If the marker radiation strength, or its percentage of modulation, drops below a certain level, or if the marker identification signal keying becomes faulty, the red light flashes and the siren sounds.

SPLIT-SECOND TIMER

Utilizes Accurate Capacitor Charging

IN AN electronic timer developed recently by Paul B. Weisz of the Franklin Institute, a capacitor is charged for the exact duration of the time interval to be measured. The capacitor voltage resulting from this charge is then measured with a vacuum-tube voltmeter calibrated to read from 0 to 140 microseconds with an accuracy of better than two millionths of a second. Uses of the timer include determining projectile velocities by measuring the interval between passage of the shell through two spaced pick-up coils mounted beyond the barrel of the gun, measuring propagation velocities and reaction rates, and measuring time lags of relays.

Explosives - - Inside and Out

Some of the Chemical "Whys" of Black Powder, Nitroglycerine, Guncotton, Smokeless Powder, Toluene, Picric Acid, TNT, Ammonium Nitrate, Amatol, and the New Penthrite which is no Longer Hush-Hush. The Basic Chemistry of All these Explosives is Relatively Simple

By SIDNEY J FRENCH
Professor of Chemistry, Colgate University

IN THE motion picture, "Destination Tokyo," occurs a breath-holding sequence. Slim crawls through a small opening in the broken superstructure of the submarine *Copperfin*, to remove, with realistic fear, the fuse from an unexploded, well planted Jap bomb. Once the fuse has been removed no one pays further attention to the bomb. For all the audience knows, that bomb remains embedded in the submarine's superstructure for the duration. Even though the *Copperfin* is depth-charged all over Tokyo Bay—and there is plenty of concern aboard—no one aboard seems concerned about the bomb, or

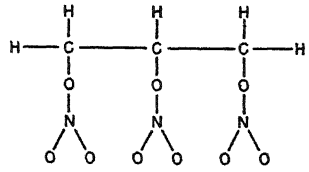


Figure 1

for that matter, about the glistening assortment of potent TNT-bearing torpedoes making up the *Copperfin's* own deadly cargo.

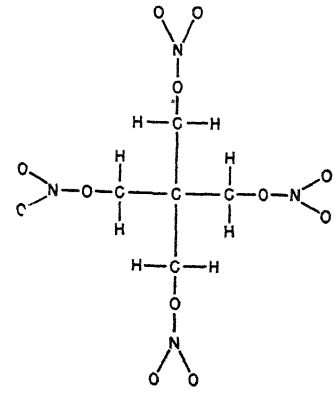
Neither the bomb nor the torpedoes will explode. Jar them, shake them, drill them, drop them, saw them—nothing happens. Even hammer them (lightly) or shoot through them with a rifle bullet and nothing may happen.

How can an explosive be so violent and at the same time so lethargic? Yet there are explosives which will actually blow up at the drop of a hat, or the tickle of a feather.

Explosives are, in fact, like people. Some lose their cork at the first sign of irritations; others will take a lot of punishment before they let go—but when they do, look out! Lazy explosives blow hard. And just as it takes many sorts of people to make a world, so, too, it takes many sorts of chemical elements to make an explosive.

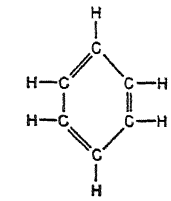
Most important, and basic to nearly all explosives, is the very anti-social element nitrogen. Though it makes up four fifths of the air we breathe, it is merely an inactive partner in the loose firm of oxygen and nitrogen; oxygen does the work, nitrogen looks on. Two tiny invisible nitrogen atoms grasp hands thus $N \equiv N$ to form a self-satisfied, lazy, and anti-social molecule of nitrogen gas. The chemist writes it N_2. It took science a round century to learn how to break the deathlike handclasp between two nitrogen atoms and to force the unhappy divided nitrogen twins into "shotgun" marriages with atoms of other elements And, like most shotgun marriages, these result in an unhappy—if not unholy—state of affairs. Nitrogen atoms will go to violent extremes to break the unnatural wedlock and return to the close comforting embrace of its twin.

Take the case of nitrogen tricked into marriage with the element iodine by the chicanery of the chemist. The union is so repulsive to both elements that it remains intact only so long as the fellow with the shotgun remains close by. This fellow is water. Let the water evaporate and the dry, unstable compound of nitrogen and iodine (the chemist calls it nitrogen triiodide and gives it the label, NI_3) is all ready to demolish itself and everything else in the neighborhood. Now drop your hat, or tickle it with a feather, or just sit patiently by while a curious fly investigates. A loud noise and purplish vapors of free iodine result. Or perhaps the slight jar of a distant footfall, an opening door, or a loud voice will be sufficient to dissolve the marriage. Obviously, such a supersensitive explosion could have little military value.



PENTHRITE
Figure 2

On the other hand, nitrogen can be



BENZENE
Figure 3

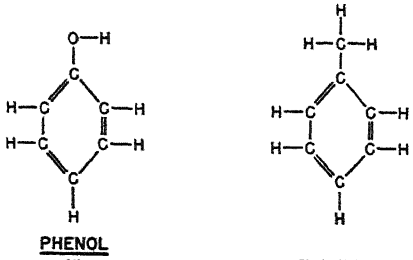
forced into marriage with oxygen by chemical trickery and the marriage is reasonably successful. If there is no happiness, there is at least no great repugnance. It will take a lot more than a dropped hat, a tickling feather, or a curious fly to break up this union. Here comes the next chemical trick. The marriage which chemistry made, it must now break—by trickery. Oxygen is the most gregarious element known. If nothing better offers, an atom of oxygen will twin up, as does nitrogen, with a fellow oxygen atom. But the embrace is light and airy, not the clasp of death. When some other fair charmer strolls around, the light embrace is quickly broken; the oxygen atoms vigorously grab new partners. Preferred as partners are atoms of hydrogen (H), sulfur (S), and carbon (C), or perchance the atoms of an active metal such as magnesium (Mg) or aluminum (Al). With each of these, oxygen has a *burning* desire to unite and with each it is willing to remain till death. The trick is simple; the marriage between oxygen and nitrogen is broken by presenting to oxygen one or more of these fair charmers—sirens capable of breaking so light a marital tie with dispatch and commotion. Nitrogen becomes free again while oxygen gains its burning desire.

Black gunpowder is a pulverized

mixture of sulfur, charcoal (carbon), and saltpeter. The chemist knows saltpeter as potassium nitrate and writes the formula for it, KNO_3, the K standing for potassium (Latin, *kalium*). Here we have all of the necessary ingredients for a marital mix-up. Nitrogen is wedded to oxygen; oxygen is quite ready to desert this tie for a happier one. The sirens, carbon and sulfur, are present to disturb the peace. A lighted match or a spark sets these unhappy atoms into action. Nitrogen breaks loose; oxygen atoms, delighted, quickly wed themselves to sulfur or carbon atoms, producing the pungent fumes of sulfur dioxide gas (SO_2) and the odorless carbon dioxide gas (CO_2). Enough oxygen is left to satisfy the needs of potassium. And all the complicated exchanges are accomplished in the twinkling of an eye to the great pleasure of those concerned.

If this were all that happened there might not even be an explosion. A handful of solid black powder produces some ten gallons of the mixture of nitrogen, sulfur dioxide, and carbon dioxide *gas*. Here is the other great secret of an explosion—the conversion of a small amount of solid or liquid into a large amount of gas—sudden expansion sufficient to shatter buildings or push massive projectiles from a 16-inch gun a distance of 30 miles.

And herein, too, lies an important difference in explosives. Some let go with shattering suddenness; these are the bursting charges or high explosives such as TNT, tetryl, picric acid, dynamite, nitroglycerin. Others let go more



PHENOL or CARBOLIC ACID

TOLUENE

Figure 4

gradually and thus push instead of shatter; these are the propellants such as black powder and smokeless powder.

Black powder was used by the early Chinese. It was mentioned by Roger Bacon in 1270 A.D. It was first used in wooden cannons in the battle of Crécy in 1346, and up to less than a century ago it was the only military explosive used. Then came a new idea. Why *mix* the several ingredients together? Why not have atoms of all of the necessary elements tied loosely together in one unhappy, unstable molecule. In 1847, chemist Sobrero found that when he treated glycerin with nitric acid he got just such a molecule. It was the very potent and explosive nitroglycerin.

Figure 1 is the chemist's picture (structural formula) of a nitroglycerin molecule. It takes but one glance to see the unhappy state of affairs in this family molecule. Oxygen is linked to nitrogen; it would much prefer carbon or hydrogen. Hydrogen is linked to carbon, it would much prefer oxygen, so would carbon.

Highy sensitive, but not supersensitive, liquid nitroglycerin can be caused to explode even by the sudden clanging of cymbals, yet it can be wheeled safely in rubber-tired carts, ladled, and poured. And when it does explode there is no hesitation, the re-shuffling of atoms takes place far faster than a flash of lightning—to produce the gases, carbon dioxide, steam (H_2O), and nitrogen. Truly, here is a *high* explosive

To tame this very sensitive substance, Alfred Nobel had the happy thought of soaking it up in sawdust and earth and thereby invented useful dynamite which still packed the wallop of nitroglycerin but was safe to handle.

While Sobrero was experimenting with nitric acid and glycerin, chemist Schöenbein was doing similar tricks with nitric acid and cellulose. Cellulose, the principal stuff of cotton and wood, has a molecule something like that of glycerin but twice as long and with six instead of three carbon atoms linked arm to arm. From these experiments (after a number of unpremeditated explosions costing lives and factories) came nitrocellulose or guncotton. Less sensitive than nitroglycerin, it is still too sensitive for comfort—and highly inflammable. Luckily it was later discovered that moist guncotton is not only safe but can be exploded if primed with a little dry guncotton.

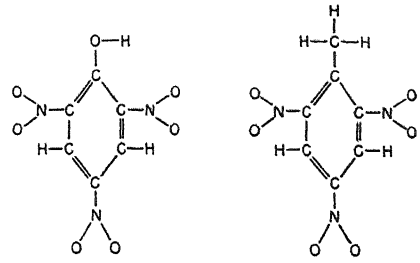
Here were two new high explosives of great value—but what was really needed was a new powerful propellant to take the place of black gunpowder Both nitroglycerin and nitrocellulose exploded too suddenly (the scientist would say they were too brissant). The job was to slow down the explosion. In 1886, Vieille treated nitrocellulose with a mixture of alcohol (no wonder there is little beverage alcohol today) and ether. The result was a tough, horny substance much like the collodion or Nu-Skin of the drug store. It was more than that, however; it was a slow burning explosive which left no smoke. In short, it was smokeless powder. Soon, Nobel had done similar tricks with mixtures of nitroglycerin and nitrocellulose. King for five centuries, black gunpowder was forced to abdicate in favor of this new king of propellants—made from high explosives. In effect, the unhappy high explosive molecules had been dropped in cold molasses where their boundless energies became both bounded and slowed down.

There are many other important high explosives with molecules similar to those of nitroglycerin and nitrocellulose. Even the manna of the Bible can be nitrated to yield an important high explosive, nitromannite—so sensitive that it is used as a substitute for fulminate of mercury in detonator caps.

Then, there is penthrite. The chemist calls it pentaerythritol tetranitrate and pictures it as in Figure 2. Its name stems from its five linked carbon atoms. Like its relatives it is highly sensitive —a quick change artist and a top-notch explosive for demolition jobs.

For many months before and immediately following Pearl Harbor, penthrite was to be mentioned only in the right places at the right time. It carried—and still carries—a mysterious symbol. Penthrite is no longer a secret; our enemies know all about it—know what damage it can inflict, how and where it is used.

There is one thing they do not know —we hope. They do not know how to make it quickly, economically, and safely. We do, thanks to the interchange



TRINITROPHENOL or PICRIC ACID

TRINITROTOLUENE TNT

Figure 5

of information between the allies—and thanks to the Canadian, Dr. James H Ross, who was largely instrumental in developing the methods

It seems evident that these explosives, involving, as they do, carbon atoms strung together in chains and festooned with hydrogen, oxygen, and nitrogen atoms, are all sensitive, fast, high steppers. Only by a molasses-like process can they be slowed down. Then, they become useless as high explosives. Where do we turn to find that ideal high explosive, the one that can be roughly but safely handled and yet explode with the best of them when properly induced?

We turn to another family of carbon festooned molecules. The chemist calls members of this family the aromatics because of the many pleasant odors among them. Instead of a festooned *string* of atoms, we have a circle of atoms, usually six carbon atoms to a circle or hexagon (Figure 3). This is the famous benzene hexagon—the molecule of benzene as the chemist pictures it.

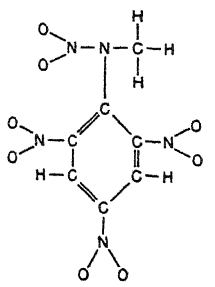
First cousins of the benzene molecule are phenol or carbolic acid and toluene (Figure 4). Now, by means of a simple chemical trick involving treatment with nitric and sulfuric acids, these basic non-explosive molecules are converted to high explosives which the chemist pictures as in Figure 5. Here are two famous explosives. Picric acid was a favorite in World War I when toluene was scarce. TNT has been the favorite high explosive for more than 40 years.

Both of these explosives are as nearly foolproof as an explosive can be and still explode. Picric acid does have the bad habit, however, of attacking metals and forming with them dangerously explosive compounds. Hence, shell or bomb cases must be lined with paint or varnish. A huge ammunition dump of picric acid has been known to burn to the ground without an explosion. TNT can be sawed, drilled, or dropped

ploding. It is quite insensitive to blows but can be exploded against a metal surface by the severe impact of metal. A rifle bullet is likely to have little effect unless the explosive is in a metal container; in small amounts it burns without exploding.

Why are these explosives so slow to anger while nitroglycerin and guncotton are so irritable? It is all in the molecule. Note, for example, that the nitrogen atoms are attached directly to carbon atoms with no intervening oxygen atom. Note, too, that the circle holds the carbon atoms in place, as it were; while in a chain the atoms are free to twist about Then, too, each carbon atom extends double arms to one partner, making the task of breaking the ring more difficult. Taken all in all, these ring explosives are a far happier family than the chain explosives. It is no wonder that they are the more popular with those who must handle explosives.

If these molecules are so slow to anger, how is it possible to make them explode at all? Here comes in another simple trick. One small match can serve to start a great conflagration if the materials are properly arranged: Paper, shavings, light sticks, large sticks, logs, in that order. One small match applied directly to the log is wholly ineffective To ensure the explosion of TNT it is necessary to use a bit of booster which is nothing more nor less than a sensitive high explosive. Tetryl (Figure 6) is the favorite booster for TNT. In this unhappy molecule one nitrogen atom is linked by one hand to another nitrogen atom—a tantalizing state of affairs. It can hardly wait to entwine its twin with the other two arms. When this starts, the rest of the unhappy molecule is also torn asunder and re-assembled into happier units. Thus, sensitive tetryl serves to stimulate insensitive TNT to let go.



TETRYL

Figure 6

But even tetryl must have more than a tickle to set it off. A mixture of highly sensitive fulminate of mercury and potassium chlorate is included in the bomb cap along with the tetryl. A firing pin sets off the fulminate which explodes the tetryl which in turn explodes the TNT. Thus, a few grains of fulminate of mercury initiate an explosion capable of demolishing massive buildings.

Even detonators or primers such as fulminate of mercury and lead azide depend on the anti-social nature of reactions. The chemist pictures these detonators in Figure 7. (Hg stands for mercury and Pb for lead.) In the fulminate, mercury has little love for plebian, gregarious oxygen (for mercury is a noble metal) and is quite willing to sever the degrading tie Nitrogen, of course, is always willing. Carbon and oxygen are ever ready to get nitrogen out of the way and embrace each other. In lead azide note the tantalizing situation of the nitrogen atoms, almost—but not quite—free to go into triple-armed embraces. No wonder lead azide is a fast-stepping detonator.

Most surprising, perhaps, of all explosives is a staid old friend. Every college freshman who takes chemistry has been introduced to ammonium nitrate—the chemist labels it NH_4NO_3 The freshman puts some of this white, innocent-looking material in a flask, heats it gently; bubbles appear, out comes a gas. This gas is the well known dentist's aide, nitrous oxide or laughing gas (N_2O). Note what has happened—the hydrogen of the ammonium nitrate teams up with the oxygen to form two molecules of water (H_2O) leaving the two nitrogen atoms teamed up with one oxygen atom, thus:

$$NH_4NO_3 \rightarrow 2\ H_2O + N_2O$$

The freshman whiffs the gas and imagines that he feels like laughing He might feel less of laughter and more of awe, however, had he realized that he had just been handling one the best high explosives known to man He need not fear, however, for ammonium nitrate is quite insensitive. Alone, it behaves as any gentlemanly chemical should—breaking up quietly into nitrous oxide and water when heated, refusing to explode even when dropped, sawed, bored, hammered, or shot full of holes.

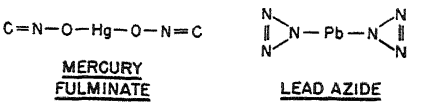
Mixed with TNT, or other high explosives, however, and strongly detonated, it loses its gentlemanly behavior and in the contagion of the moment explodes with startling violence. This time it breaks up not into nitrous oxide and water but into nitrogen gas, steam, and oxygen.

In World War I there was a great shortage of toluene, basis of TNT. It could be obtained only as a by-product in the production of coal gas. Strong measures were needed to maintain the supply of TNT. City gas mains were stripped of their small quantities of toluene. Still there was not enough. In desperation, almost, the scheme of diluting TNT with ammonium nitrate was tried. It worked. It not only worked; it even gave a superior explosive.

Used first in small amounts, the percentage of ammonium nitrate was gradually increased till instead of being merely a diluting agent it became the main ingredient of this mixed explosive.

Today there is no shortage of toluene. Chemists have learned how to make it from petroleum products. The tails of long carbon chain hydrogen festooned molecules of gasoline are twisted to make toluene rings out of the chains.

toluene or TNT in this war, even though we could now get on without using ammonium nitrate to dilute the TNT, there is little likelihood that we will try it—for the simple reason that for many purposes the mixture is superior to TNT alone. Each ingredient complements the other. TNT is short of oxygen; ammonium nitrate has an excess of oxygen. There is just enough extra oxygen in ammonium nitrate to tie up with the unhappy left-over carbon atoms in the TNT. The result is an explosive which is almost smokeless—and fully as powerful as TNT alone If smoke is wanted, it is only necessary to include a smoke box. This mixture of ammonium nitrate and TNT is known as amatol (abbreviated from the names). Many other mixed explosives



MERCURY FULMINATE

LEAD AZIDE

Figure 7

also contain ammonium nitrate The only necessary condition to be observed is that there be present a sufficient quantity of a more sensitive high explosive to set off the relatively insensitive ammonium nitrate. Ammonal, containing a little charcoal and aluminum powder as well as amatol, explodes with a brilliant flash, making night observation of hits an easy matter. Dynamites often make use of the power locked up in ammonium nitrate.

Truly this innocent, useful chemical, so harmless in a peaceful environment, can become a giant among explosives when properly teamed with other more active giants It is indeed one more example of the versatility of these important nitrogen compounds.

What happens when the firing pin of an artillery piece strikes the priming cap of a high explosive shell? Fulminate, on being thus crushed, emits a spark; combustible chemicals pick up the torch and carry it forward, enlarged, to an ignition charge of black powder. Here real conflagration begins which is passed on to the main propellant charge of even-burning, high-pressure-producing smokeless powder. The projectile can move only forward—and it does, gaining speed and power on the way.

When this projectile strikes its target a similar process is repeated. This time the firing pin, driven backward (sometimes forward), initiates a stream of fire through the detonator, through a train of black powder the length of which can be adjusted to time the instant of explosion, to the booster tetryl. All these are in the cap. Then comes the culmination of this complex series; TNT lets go with all of its destructive fury.

Explosives today have special jobs to perform. Roughly they are classed into primers, igniters, propellants, boosters, and bursting charges, but it is a rare explosive that does not have at the bottom of its structure and behavior the all-important anti-social key element, nitrogen.

High-Octane Gas

What Effect will the Wartime Advances in Technology and Plant Facilities that are Giving Remarkable Fuels to Aviation have on Post-War Uses, Air and Automotive? Will You Fly with 100-Octane Gas and, More Immediately Interesting to the Average Reader, Will You Drive With it?

THE WAR has seen tremendous advances in high-octane fuel technology and in the growth of the nation's facilities for manufacturing such "super" gasolines. It is to be expected that the greater number of the new plants will be diverted to other purposes once the war is over, but many will remain dedicated to their present uses.

The heat contained in a fuel and air mixture has an equivalent in work-possibilities, but it cannot all be converted into work after completing its task unless temperature of the burned fuel at the exhaust is reduced to the deadly cold of absolute zero. In the internal combustion engine, of course, the burned fuel has to exhaust at temperatures well above that of our ordinary atmosphere. Another factor which determines the efficiency of heat conversion into work is the highest temperature which the internal combustion engine attains during its working cycle.

There is little to be done about the temperature of the exhaust, but the highest temperature attained within the cylinder can be raised by increasing the compression ratio—the rise in pressure during the compression stroke. With a compression to 70 pounds a square inch, the efficiency of the gasoline engine is only about 20 percent, at 150 pounds it may be as high as 30 percent. There is, however, a definite limit to the compression ratio and the resulting temperatures which it is possible to use in the engine, because when these are raised to a high point there may occur pre-ignition or detonation—closely allied though not identical phenomena.

Supercooling the engine is not the method of approach, since excessive cooling means loss of power. The modern alternative is to use fuels or doped fuels which will not knock at very high compression ratios and the accompanying high temperatures.

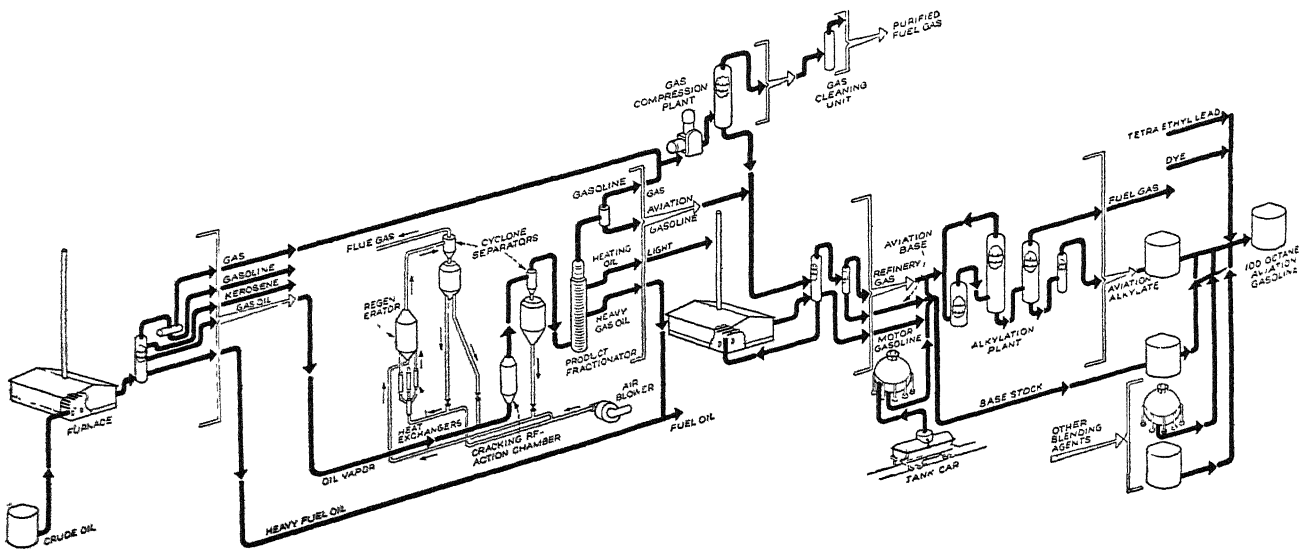
Besides inventing anti-knock fuels, chemists had to establish a measure of their qualities. Years ago they devised a method of grading by "octane numbers." It was found that a certain hydrocarbon, iso-octane, is a good anti-knock fuel, while another hydrocarbon, normal heptane, is very poor. To the former is given the knock rating of 100; to the heptane the value 0. Single cylinder knock-testing engines are employed to measure these properties. If a fuel is found to have the same anti-knock characteristics as a mixture of 70 percent iso-octane and 30 percent normal heptane, it is said to have an octane number of 70.

Just because iso-octane has a rating of 100, there has arisen the misconception that 100 is the highest rating attainable. Nothing could be farther from the truth. A fuel which has better anti-knock properties than iso-octane has a considerably higher rating.

An ordinary automobile gasoline has a rating of 70 to 75. High-test aviation gasoline can easily have a 90- to 100-octane number.

FOUR SOURCES—Aviation fuels derive principally from different series of hydrocarbons—paraffins, olefins, naphthenes, and aromatics—each with its own peculiarities and characteristics. There are innumerable ways in which the carbon and hydrogen combine, and the carbon atom can hold on to two or more atoms of hydrogen. Just the names of some of the combinations sound intriguing: methane, ethane, butane, hexane, and so on. It is on the arrangement of these atoms, straight-chain and branched-chain; on the length of the molecule; and on similar properties; that anti-knock characteristics depend.

Not so long ago the petroleum refiner had to be content with using combinations in the manner in which nature provided them, but now they are trans-



Courtesy Standard Oil Company (New Jersey)

Simplified flow diagram showing production of 100-octane gasoline from crude oil

formed and combined in the most extraordinary manner.

A process called "catalytic alkylation" is used to combine butylene and isobutane to form iso-octane and to produce combinations far superior to iso-octane. The raw materials are introduced as gases into the cracking coils of a refinery and, by cracking, by application of heat and pressure, by distillation, iso-octane and other anti-knock compounds are formed.

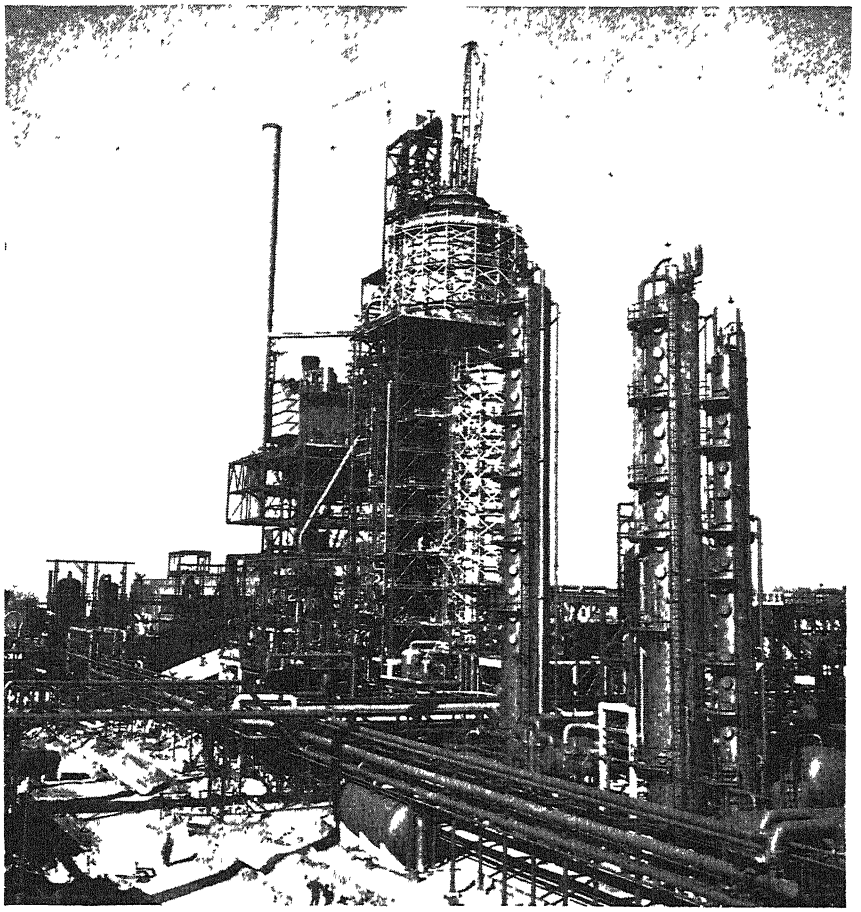
With improvement in technology there has also come decrease in costs of production, and this decrease has come very quickly The first commercial plant to produce iso-octane by alkylation was built late in 1938, only a year before the war, but the price already has dropped from $20 to less than 15 cents a gallon. Moreover, the rate of production of high-octane gasolines has grown to stupendous proportions—how else could we keep our Flying Fortresses and Thunderbolts in the air?

TEAR DOWN, REASSEMBLE—Modern aviation gasoline is the climax of a series of separate and, in some cases, extremely complicated, chemical processes. It is no longer a question of merely distilling crude oil to "recover" its gasoline content. The modern fuels are synthetic products which result from chemically tearing apart the petroleum molecule and then reassembling it into anticipated chemical patterns. We are indebted to the Standard Oil Company (New Jersey) for the simplified flow diagram shown in one of our illustrations. The crude oil is first heated in a specially designed furnace, in which is started the first separation into the principal petroleum fractions—of which gasoline and "gas oil" are of principal importance as far as high-octane aviation gasoline is concerned.

The "gas oil" is "cracked," which is the chemist's name for a literal cracking up of the petroleum molecule under heat. The cracking occurs in the presence of a finely dispersed catalytic powder which is carried along with the vaporized gas oil during the cracking reaction This powder controls the way in which the moecules are first cracked and then re-combined to form the desired types of chemical compounds. Following the catalytic cracking, high-grade aviation gasoline is separated for use as a base stock for super fuel. The gases produced in the catalytic cracker are compressed so as to separate highly important compounds which go to the alkylation plant.

The alkylation plant in itself constitutes a complicated chemical step. In the alkylation plant and under the influence of an entirely different type of catalyst, the specially segregated gases both from the crude and from the cracking process are combined to form the high-octane synthetic aviation alkylate. The final blend of 100-octane gasoline includes base stock, alkylate, and sometimes other special blending agents. To all this is added the requisite amount of tetraethyl lead.

The flow diagram appears simple but when the process is realized in steel and other materials it is embodied in huge criss-crossed pipes, gaunt steelwork skeletons, and massive silhouettes of tanks and towers



The "Baltimore Giant," Standard's fluid catalytic cracker

It takes a year or more to build a new plant to make 100-octane gasoline, even in peace time. Yet in 1943 more than 72 new major plants were built, and the product output has been quadrupled, then doubled, then doubled again. The war-time expansion has been stupendous. The opinion has been voiced that after the war all this enormous plant capacity will remain to provide 100-octane gasoline for every motorist. It is more correct to say that the manufacture of high-octane gas on this stupendous scale will not continue after peak military demand has ceased and the Government ceases to be a willing customer of 100-octane regardless of cost. The facilities remaining in active operation will, however, suffice to support military and naval aviation on a higher scale of operation than pre-war, to support commercial air transport and private flying of great proportions, but will be used in the automobile on only a small scale.

What does high-octane gas do for aviation? It allows us to crowd more power into the aviation engine, to use the gasoline more efficiently, and to improve military performance beyond measure. Thus, for the same gross weight at take-off a plane using 100-octane gasoline can fly 20 percent farther than a plane which uses only 87-octane. A heavy bomber flying to an objective 1000 miles distant can carry five more 1000-pound bombs than one using 87-octane. Greater power for the same weight of engine means much to our airmen the ability to carry better armament, more bombs, to fly from smaller fields. The American superiority in making higher powered gasoline, and in making vastly more of it, is a vital element of our superiority in the air to the Germans and Japanese.

THE REASONS—We can also define the beneficial effects in slightly more technical language: Engine power is directly proportional to the intake manifold pressure and the amount of supercharging. The higher the octane rating the higher is the permissible intake manifold pressure without danger of detonation.

Again, the greater the knock rating of the fuel used, the higher can be not only the intake manifold pressure, but also the compression ratio and the mean effective pressure in the cylinder.

It is interesting to note that aircraft engines today are no higher in compression ratio than automobile engines (with ratios varying from 6·1 to 6.7:1). If their compression pressures are very much higher, this is because they are supercharged for power. This is the reason why the aviation engine is so much more susceptible to the wiles of high-octane gasolines.

The improvement in airplane performance with 100-octane gas is startling but the skill of American technologists has gone even further, and they may, by now, have attained 130-octane and even 160. Military secrecy guards further disclosures today but

newspaper stories carry hints of wonderful things to come Thus, Dr. Gustav Egloff, president of the American Institute of Chemists, told a conference of the National Association of Manufacturers that we now have an airplane fuel which is 50 percent superior to iso-octane and is likely to give the Allies even greater superiority in the air. The new "supergas" is called triptane (paraffinic - trimethyl - butane) While the world has known of the gas for seven years, it is only now that methods have been developed by the Universal Oil Products Company for manufacturing triptane on a commercial scale and the original price of $3000 a gallon has been reduced to less than $11 a gallon. The anti-knock properties of triptane are of such magnitude that no commercial engine has been built which is capable of utilizing its full power value.

Sun Oil also has a gas of great power —Dynafuel, 50 percent more powerful than standard 100-octane fuel. Dynafuel is never used undiluted but is blended with 100-octane gas. Other companies, no doubt, have similar developments

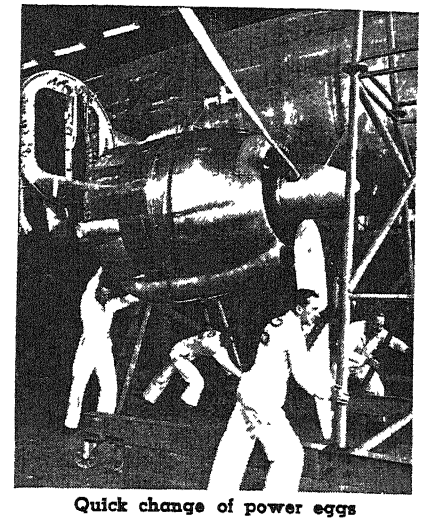
In the motor car, gasoline is a vital element of cost. The average private owner does not put a figure on his own services while driving, and makes no analysis of insurance or depreciation costs. But mileage per gallon is likely to loom quite largely in his mind. In scheduled aviation the situation is quite different. Pilot's pay, depreciation, maintenance costs, and so on, are far more important than the cost of the fuel. Further decrease in the actual weight of fuel to be carried is a far more important matter than its cost. The payload of the airplane, particularly on long ranges, is likely to reach a low percentage of its gross weight, and when the payload decreases the cost per ton mile increases inordinately. Hence, in civil aviation almost as much as in military aviation, the emphasis will be on specific fuel consumption rather than on fuel cost Anything that increases the power and fuel economy of the engine therefore is eagerly welcomed. Thus 100-octane gas at 16 cents a gallon will be chosen without hesitation in preference to 91-octane at 13 cents. We venture the prediction that air transport will take the highest number it can get.

IN YOUR CAR?—Predictions have been made regarding the use of 100-octane gasoline for the post-war motor car. We believe that these predictions are extravagant. Everything seems to indicate that the post-war motor car will not be so very different from the 1942 models. Manufacturers are much more likely to resume production on the proved models than to seek radical changes in design and delay resumption of manufacture. And the pre-war cars did not really need much better gasoline than the 75-octane variety.

There are avenues of approach to economy in the motor car other than in high compression and high-octane gas. Engine speed can be reduced, automatic transmissions can help, lighter materials can reduce ground friction and therefore the horsepower. To take full advantage of advanced gasolines we would need completely redesigned, expensive engines Normal fuels will still be cheaper than the 100-octane gas, and post-war trends are likely to be in the direction of economy. Furthermore, our oil resources are decreasing and we shall be forced to use those methods which give us more fuel for a barrel of crude Certainly, as a result of the war, we shall be able to buy at wayside stations fuel several octane ratings higher than pre-war. But, by and large, 85-octane is likely to be the highest knock rating which can be used effectively by automobiles in the immediate post-war period.

Mr. A. T. Colwell, Vice-President of Thompson Products, in a paper presented before the Society of Automotive Engineers, has expressed some very interesting views. "We can make the fuel, but what about the automobile engines? There is nothing to be gained in using high-octane fuel in an engine not designed for its use—that is an economic waste of octane numbers. Greatest efficiency is obtained from fuel when it is on the verge of knocking." And again: "Only a portion of our high-octane fuel capacity—about 10 percent of our total capacity—will be used by aviation after the war The excess capacity will be available for automobiles, *if it can be utilized.*"

In conclusion: So far as aviation is concerned there is scarcely a limit to the octane rating of fuel which can be utilized and for which the industry will be glad to pay high prices. When, however, it comes to the post-war automobile, it is probable that the growth in use of high-octane fuels will be much slower—because the automobile engine of immediate post-war will scarcely need it, also because the trend will be to economy, and because our diminishing petroleum resources will force us to be wary of producing high gasolines with lesser yields per barrel of crude



Quick change of power eggs

POWER EGGS

Changed in Quick Time on Lockheed Constellation

To reduce ground time in maintenance of a transport airplane is a vital factor in operating costs. An example of progress in this direction is the Lockheed four-engined C-69 Constellation, in which it is now possible to make a complete change of power plant in 27½ minutes. Our photograph shows one of the steps in this quick change, which has been carefully timed by Lockheed design engineers.

To achieve this remarkable interchangeability, particular attention was paid to the grouping of the lines, ducts, and connections at the fire wall, with quick disconnects of all units. Collector rings on the big Wright twin-row 2200 horsepower engines exhaust through two jet-type tail pipes that protrude through the cowling of the power-egg itself. The nacelle is fixed to the airplane at the fire wall by only ten bolts, all readily accessible

A regular sequence of disconnections is followed Carburetor air-scoop removed; disconnections started at fire wall; hoist sling secured; engine ready to be lowered; engine swung aside and lowered; new power plant swung into place preparatory to securing structural connections; engine in place; structural, electrical, hydraulic, and cable connections being made; new power plant completely installed, ready for propeller—all in 27½ minutes.

THE LOCKHEED LIGHTNING

Is Now Faster, Carries Heavier Load

For some time many independent authorities clamored for long-range fighters to protect our bombers. The official answer was that the bombers were so well armed that they needed no fighter protection But they did need protection, and our Flying Fortresses and Liberators could not possibly carry out the present damaging attacks on German cities and war plants without the aid of Thunderbolts and of the P-38, as the twin-engined Lockheed Lightning is called. It is quite true that we have introduced few new models to the war fronts since Pearl Harbor but, on the other hand, the models that existed before the war have been improved beyond all recognition.

Thus the P-38 is now capable of flying over Berlin from British bases and is the twelfth model of the Lightning It is now capable of carrying two 1000-pound bombs—double that of any single-engine fighter—and packs the heaviest bomb load of any fighter-bomber. The power has been increased from 2300 to 3000 horsepower. The rate of climb has been increased 100 percent at altitudes over 30,000 feet and materially increased at all altitudes, while service ceiling is well over 40,000 feet Single-engine speed is now over 300 miles an hour. Combat maneuverability has been improved by mechanical aids to the pilot in the form of hydraulic aileron boosters combined with the old combat flap, while new power and temperature controls facilitate the task of the pilot. Armament remains heavy.

Water Conditioning

Master Chemical of All Chemicals, Water Produces as Many Industrial Headaches as it Solves. However, Intensive Research on the Whole Water Problem is Pointing the Way Toward Treatment Methods Adaptable to Almost Any Troublesome Situation in Factory or Home

By J. D. RATCLIFF

ONE OF the earth's most amazing chemicals is ordinarily taken completely for granted That chemical is water. It may be either hard or soft, muddy or clear, good or bad tasting Taste gets most emphasis, yet we drink only a quart or so of water a day, whereas we use 50 to 75 gallons daily for other purposes.

Instead of being so concerned about the taste of water, we might better ask: Does it clog hot-water pipes with minerals? When mixed with soap does it produce a hard curd that seals pores and causes skin disorders? Does it leave a gritty deposit which makes hair dull and lusterless; shaving a painful daily ritual?

Answering such questions as these keeps scores of research men busy. They work steadily to solve problems posed by that amazing fluid that gushes forth every time we open the tap at the kitchen sink. Yet few of these men have ever seen absolutely pure water—rare among laboratory chemicals. *Pure as the driven snow* is a pretty phrase—but as wrong as it is pretty. Even the snow that falls on the North Pole, even the rain that drenches tropical forests, is contaminated. It contains considerable amounts of dissolved gases, dust, spores.

Because water is the universal solvent, really *pure* water is never found in nature. To some extent it dissolves everything—even solid rock, glass, or gold. As it flows through rock strata it picks up a little of everything it touches. It dissolves carbon dioxide, producing naturally carbonated water. When it dissolves natural gas in the ground, we see that amazing phenomenon of water that gives off inflammable bubbles.

This solvent action poses staggering problems for industry. As little as one part of iron in two million parts of water can wreck a textile mill by staining cloth. Traces of minerals upset the delicate chemistry of rayon making. Boiler scale, formed of the minerals left behind by hard water, is a costly hazard in power plants.

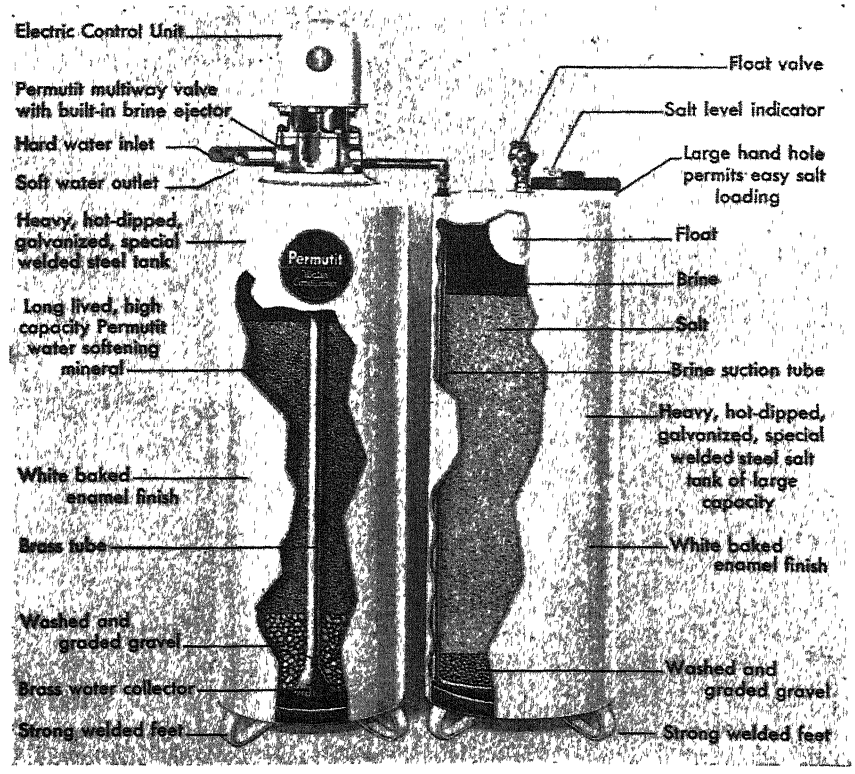
Getting rid of unwanted water components is the job of the research men. They have devised dozens of delicate chemical processes to do the work and are constantly seeking better methods. Many of them are at work in one of the most fascinating laboratories in the country—that of the Permutit Company. It is the world's largest laboratory devoted to the study of water-conditioning problems.

Water hardness poses the biggest problems encountered by industry and householders alike. Hardness is governed by the quantity of calcium and magnesium compounds dissolved in water. Less than one grain (about one seven-thousandth of a pound) of these compounds per gallon makes water objectionably hard for certain industrial uses. For general household use, though, water that does not contain more than a few grains of hardness is usually considered to be soft water

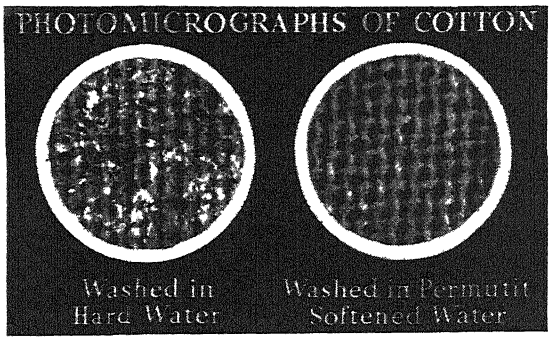
TWO THIRDS OF THE NATION—New England, the South (except Florida), and the Pacific Northwest have fairly soft waters. The rest of the United States has hard water of varying degree, the central tier of states having the worst problem. Thus, hard water is a headache to approximately two thirds of the people of the nation.

Hard water smudges glasses, dishes, and silver, leaves a rancid, sour smell in linen. Minerals from such water are deposited in hot-water pipes—often reducing the bore of a six-inch pipe to one inch in relatively short order This scale has insulating properties virtually equal to that of fire brick. Thus, it wastes large amounts of the fuel used in boilers and water heaters. It forms in auto radiators and in engine-cooling jackets, radically reducing efficiency.

The sticky curd that results when soap is lathered in hard water is costly to large linen users: Hotels, hospitals, sleeping cars. This curd lodges in textile fibers and may cut in half the life of sheets, towels, and pillow slips. Hard



An automatic water-softener unit of the household type



When fabrics are washed in hard water, a sticky curd remains on the individual fibers despite thorough rinsing. This curd may act to reduce the service life of the fabric by as much as 50 percent. No such deposit results when soft water is used

water is also a soap eater. To get the same amount of suds, hard-water Chicago uses twice as much soap as soft-water Atlanta.

Some foods—especially beans, peas, lentils—are excellent water softeners They take up the calcium in water, but they come out of the pot themselves hard and leathery. Some Westerners have their own measure of water hardness: If cooked beans are edible, the water they were boiled in was soft enough for all practical purposes. Any householder can get a rough estimate of water hardness by examining the bathroom tumbler. If water permitted to dry in the glass leaves a hard, chalky film, the water is hard.

Industrial water-conditioning problems pour into the laboratory. Locomotives have to be laid up frequently while scale is removed from boilers. The laboratory designs water-conditioning equipment which costs $169,000; the first year it is used it saves the railroad $300,000.

TYPICAL PROBLEMS—A filling station writes in. Local water is so hard that washed cars have a streaked, dirty look; car radiators are jammed with scale. A $200 water softener solves this one.

A hotel has a problem. Its water tastes bad and contains so much iron that linen is being ruined. An activated carbon filter is supplied which removes taste, and special softening equipment is installed to remove iron and hardness.

A commercial swimming pool finds itself confronted with huge water bills. Equipment is designed which permits re-use of the water after treatment. Pool water is pumped through filters and chlorinated so that it comes out adequately pure and make-up water is reduced to a minimum.

A beauty parlor complains that it is impossible to give good shampoos with the hard water from city taps. A small softener is installed. Incidentally, Mrs. Coolidge had a softener installed in the White House after visiting such a beauty shop. Windsor Castle has a water softener—and so has W. C. Fields!

Specially treated water is essential in scores of industries: Oil, steel, moving pictures, radio, synthetic rubber, munitions, and so on. It is desirable elsewhere: In dairies and bottling plants to insure clean bottles; in laundries where it accounts for soap savings up to 75 percent; in citrus packing plants where soft water in washers gives oranges and grapefruit a clean, bright appearance, thus commanding a higher market price

The oldest method of water softening is achieved by adding lime and soda ash to precipitate the calcium and magnesium. A newer method depends on minerals called zeolites, available in both natural and synthetic forms. These granular substances have the seemingly miraculous property of softening water. Pass water of any hardness through a bed of zeolite and it comes out of the bottom completely soft. The zeolite takes calcium and magnesium from the water and replaces it with sodium—which doesn't contribute to water hardness. In time the zeolite becomes exhausted and has to be regenerated. This is done with common salt, which gives the zeolite fresh sodium.

The base-exchange properties of zeolites, by means of which sodium is exchanged for the calcium and magnesium of hard water merely by passing the water through the zeolite, have been known for almost a century but no practical use of them was made until the early 1900's, when granular zeolites were first manufactured and equipment was designed for using them in water softening.

Chemically, a zeolite is a compound of a basic oxide, such as soda; an amphoteric metal oxide, such as alumina or iron oxide; silica; and water. There are a number of amphoteric metals—metals that can form either acids or bases—but the two most commonly used are iron and aluminum. By combining these materials in a rather lengthy process, synthetic zeolites can be produced which have distinctive properties for special purposes. Natural zeolite, which also requires processing before it can satisfactorily be used in water-softening equipment, is commonly called "greensand," and is a mineral that was originally formed under prehistoric seas. Today it is being mined by the open-pit method from deposits now on dry land.

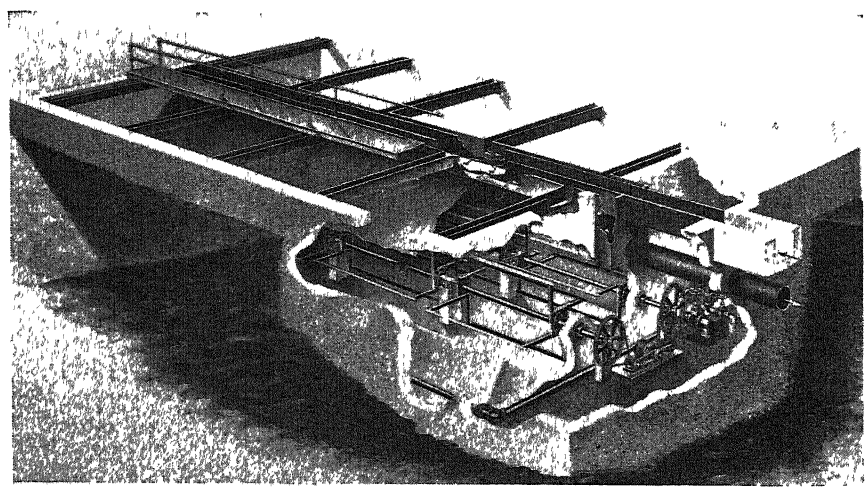
Automatic home water softeners using zeolite cost about $250 and will probably cost as little as $150 after the war, if present plans for mass-production materialize. Even less expensive equipment is available for the same purpose if the user does not mind the minor inconvenience of occasionally operating the regeneration controls by hand.

These home water softener units have much the appearance of two kitchen hot-water boilers sawed off to a height of about five feet. One tank contains the zeolite, the other the salt for regenerating the softening chemical. About once a week—depending upon the amount of water that has passed through the zeolite—it is only necessary to flip a switch on the automatic unit. This sets in motion the mechanism which backwashes the zeolite bed, regenerates it with a salt solution, and thoroughly rinses it. Accumulated hardness is washed down the drain. With manually controlled units, the same action is obtained through manipulating a couple of valves.

Because of the staggering waste caused by hard water it seems likely that water softeners will be included in all post-war homes built in the hard-water belt. One conservative estimate indicates that hard water costs the average family $117 a year—in wasted soap, unnecessary plumbing bills, shortened life of linens, ruined foods.

About 500 municipalities now soften city water supplies. Sarasota, Florida, for example, softens water from 65 grains down to 5. Sea water is used instead of salt to regenerate the zeolite softeners.

SOAP SAVINGS—After such municipal systems are installed, soap sales nose dive, sometimes as much as 70 percent! Madison, Wisconsin, estimates that it saves its citizens $250,000 a year in soap alone—in addition to such other



Cut-away section of a horizontal concrete precipitating unit for removing impurities from liquids by precipitation, adsorption, settling, and upward filtration. Such units are made in sizes handling from 1000 to 10,000,000 gallons a day

advantages that go with soft water as better tea and coffee, cleaner clothes, more refreshing baths. One water chemist boasts that he can make an accurate estimate of water hardness in any city by drinking a cup of coffee or by looking at the complexions of the people!

Large industries pay far more attention to boiler feed waters than a mother does in preparing water for a delicate infant. Twenty-five years ago good water was desirable; today it is a vital necessity to them. In this period boiler pressures have gone up from 200 to as high as 1200 pounds per square inch in some cases. Even a small amount of scale in a high-pressure boiler is an expensive hazard. It causes overheating of the tubes, with consequent failures, and increases fuel and maintenance costs. Scale is also objectionable and wasteful in cooling systems. One public utility saves $80,000 a year in fuel by softening the cooling water for its condensers.

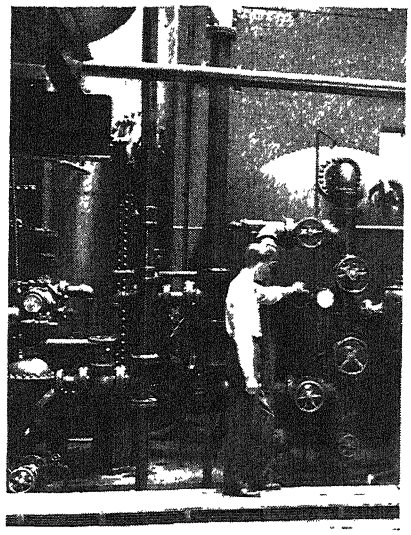
To Howard L. Tiger, director of the Permutit laboratory, water isn't just something to drink—it is something to fix. He has spent 25 years, nearly all his professional career, working at it. Among other things, he has designed chemical treating plants which can convert swamp water into the equivalent of distilled water, at a cost only one twentieth of that of distillation.

This rich background of water experience stood Tiger in good stead when war came. The armed forces have innumerable water problems besides the one of providing safe drinking water for the men. Distilled water, for example, is needed in large quantities for use in the batteries which provide power for radio and telegraphic communications. Carrying this water to the front was an awkward, time-consuming job. Did Tiger have any ideas?

He and his helpers went to work In a few months' time they came up with a piece of apparatus, no larger than a suitcase. In seconds, this "demineralizer" converts the murkiest creek water into water suitable for battery use. Here, again, zeolite came into the picture. By means of the small unit, the unwanted minerals, which would damage batteries if raw water were used, are removed. The demineralized water is found to be every bit as good for the purpose as distilled water. In fact, the demineralizing process produces an effluent comparable with or lower than commercially distilled water in mineral content. It is applicable to most fresh-water supplies but not to highly saline waters such as sea water.

SALT WATER MADE DRINKABLE—However, even sea water has yielded to the knowledge of the water experts. Flyers and seamen adrift on rubber rafts can now be supplied with a compact apparatus which takes the salt out of sea water and delivers life-giving, potable water.

Man has sought to solve this problem for centuries and has come up with some pretty bizarre solutions. These have included tiny gasoline stills, solar stills, and even a stomach still. In the latter, the man adrift on a raft pressed a flask of sea water against his stomach. Body heat caused some of the water to vaporize, and it was condensed in a tube which trailed in the cold sea water. There were chemical approaches, too, but they were all too complicated or too cumbersome. Then came the winner.



Water used in processing textiles is softened in these zeolite units

The new apparatus consists of a plastic bag, about the size of an ice bag, and chemical cartridges the size of five-cent candy bars The bag is filled with sea water and one of the cartridges is dropped into it. The chemical precipitates the salts in sea water and they are filtered out. Each cartridge, whose composition is a war secret, produces a pint of drinking water—enough to provide the needs of a man for a day. This device has been adopted by the armed forces and is in wide use.

Post-war applications of principles learned in water softening and conditioning will have wide uses. The chemical swap-shop idea encompassed in the zeolites can be used to reclaim the factory wastes often dumped into rivers. Chrome, silver, gold, and other metals used in electro-plating are being experimentally recovered from liquid wastes. One process has been worked out for reclaiming nicotine lost in tobacco curing. This should cut the cost of this valuable insecticide. Another method is available to reclaim pectin from citrus wastes. Pectin is the material that makes jelly jell.

Such applications as these will be valuable to industry. But the home owner will be chiefly interested in better water. It will give the man of the house two to three times as many shaves with the same razor blade and save him money in other ways. For the housewife it means less labor spent scrubbing sinks, tubs, clothes. Hundreds of thousands of home water softeners are now in use. Water conditioning, now well past the experimental stage, has thoroughly proved itself. It is here to stay.

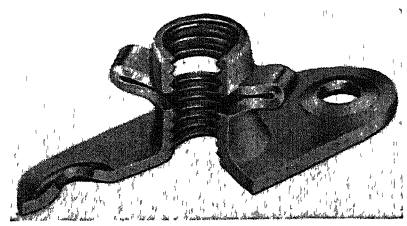
⊕ ⊕ ⊕

LOCK NUTS

Stay in Place, Save Weight

One of the mechanical problems that has plagued industry from the beginning has been that of securing machine and other parts which are subjected to vibration. Ordinary nuts, no matter how firmly they are turned into place, will loosen sooner or later as a result of vibration Accordingly, many different methods have been devised to hold bolted fastenings securely. These methods have ranged from various spring lock washers through complicated pinning arrangements to unconventional nut forms which exert a locking pressure in one manner or another.

Aviation in particular is concerned with this vibration problem. Bolted connections must remain solid regardless of vibration. Thus when aircraft production went under forced draft a few years ago, recognition was taken of the fact that welding or riveting could not do all the fastening jobs that must be accomplished; many parts had to be put together with threaded fasteners. These must hold regardless of vibration, yet must be capable of being unfastened quickly and easily.



Principle of the Boots lock nut as applied to a wing style anchor nut designed for use on aircraft

Into this gap came a type of lock nut that had been proved in service and which offered additional advantages. It was made from sheet-metal stock and was light in weight, yet gripped the threads of a bolt so tightly that no amount of vibration could displace it. So light in weight is this lock nut that, it is reported, use of it has added over 1,500,000 pounds of carrying capacity to American fighting planes.

Pictured in these colums is a cross-section of one form of this lock nut, developed by Boots Aircraft Nut Corporation. Here can be seen the one-piece construction in which the threaded part of the nut is divided into two sections. When this type of nut is applied, the bottom threaded section serves in the normal manner. However, since the threads in the top part are out of lead with the rest of the nut, tightening of the connection establishes a constant force between the threads of the nut and the bolt, thus locking the unit firmly without damage to any of the threads. Axial thread play is eliminated.

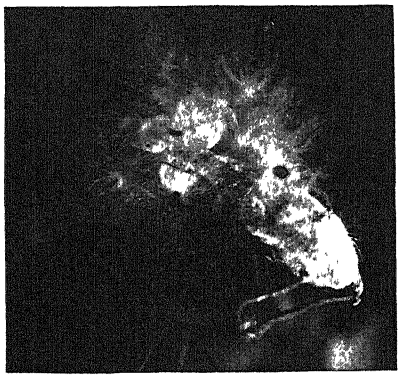
So successful has been the use of these nuts in aviation that they are

fields. They are applicable, in a variety of types, to the solution of fastening problems on automotive equipment, farm machinery, industrial and office equipment, bicycles, household appliances, and many other products.

MILKWEED FLOSS

Replaces Kapok in Life-Saving Garments

THE present intensive campaign underway throughout a large part of the United States to collect milkweed floss for use in filling "Mae West" life vests, aviators' suits, and other critical life-saving apparel is another example of the interchange of materials made necessary by war. The fiber from the tropical Ceiba or kapok tree has for a long time depended upon where the combination of high buoyancy, moisture resistance, and light weight were demanded. And the only place in the world with large kapok-producing plantations is Java. This means, of course, that we have been living on our reserves since December 1941, and



Pod, floss, and seed of the milkweed

that it will probably be several years before kapok is again available to us in the quantities required.

Although kapok is a member of the Bombax family, botanically far removed from the milkweeds, the fibers of both plants are surprisingly alike. Although kapok trees may exceed 100 feet in height, compared with only a few feet for the milkweed, both are similar in having pods from 4 to 6 inches in length, filled with woolly haired seeds. And, strangely enough, the seed hairs or floss are also very much alike. The individual fibers are about 30 to 40mm long by .005 to .03mm in diameter, tapered, and with virtually hollow air cell some five or six times as wide as the thin outer wall. Both fibers have a silky, lustrous appearance; both are light and soft; because of their springiness both fill confined spaces without packing; both are wax coated. While both are similar in the high alpha-cellulose and furfural content, milkweed floss is slightly higher in lignin. The ash content of both is nearly identical. No other material known is closely similar to these two in chemical and mechanical properties, or in actual performance.

Both have very high insulating value, milkweed being reported as slightly wool or fur. Both are very high in buoyancy value, with milkweed apparently retaining buoyancy a little longer. Milkweed has been found to be exceptionally resistant to storage deterioration and destruction by molds.

Thus while many other materials can be employed as substitutes in the numerous places formerly filled by kapok, only milkweed will do in the all-important life-saving apparel. This is why every possible pod is needed this coming fall so that no American life will be lost for lack of sufficient life-saving equipment.

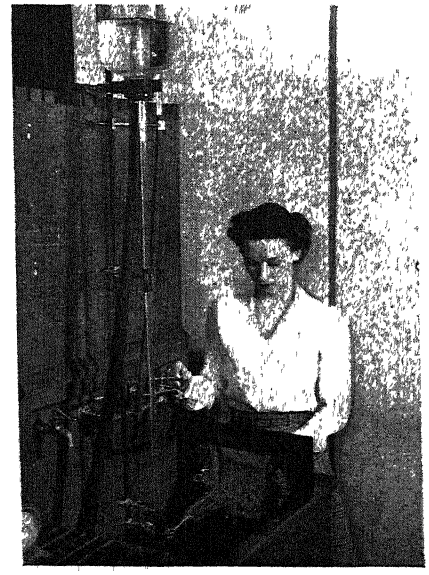
RAIN TEST

Accurately Evaluates Water Penetration of Fabrics

THE tempest in a teapot has a serious scientific counterpart, the "cloudburst in a beaker." Simulating a heavy tropical downpour, a new rain tester has been devised for evaluating water repellent fabrics, now so widely used in military and civilian garments.

George A. Slowinske, of the Du Pont Company's Fine Chemicals Division, who designed the experimental apparatus, is one of the leading authorities on the subject of water repellency and is in charge of research in this field at the Technical Laboratory of the Du Pont Dye Works.

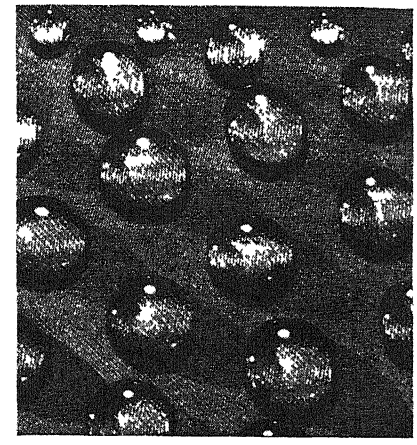
The laboratory rain maker, which has been employed in work on numerous fabrics, may still undergo changes before being offered in its final form. It consists of a shower head at the bottom of an eight-foot glass tube. At the top of the tube is a large vessel or beaker of water, supplied through a hose running up from the water faucet. This inverted shower bath arrangement provides a spray of uniform intensity, directed horizontally upon the fabric to be tested. The sample of cloth is clamped to a support board held at a fixed distance from the shower head. But back of the cloth is a piece of blotting paper. By weighing the blotting paper before and after the synthetic rainstorm, one can calculate the



Testing water repellency of fabric

treated fabric. This figure and the time required for the artificial rainstorm to penetrate the fabric give an accurate measurement of the impact penetration resistance of the water-repellent fabric By shortening the tube one may simulate lighter rains.

The rain test and other tests developed by Mr. Slowinske are expected



Water forms globules, hence does not penetrate a water-repellent fabric

to do much to remove the guesswork from the fabrication and sale of rainwear, ski suits, jackets, and other water-repellent garments. "Proper construction of the fabric and the garment are necessary," Mr. Slowinske says, "in order to obtain the full benefit of the chemical treatments. The chemicals used, including 'Zelan' durable water-repellent, make the individual fibers shed water without clogging up the pores which permit the garment to breathe. Therefore the cloth must be woven closely enough so that rain won't go through the pores

"It has been appreciated for some time that two thicknesses of a suitable treated fabric will invariably give better protection against rain than a single thickness of even the best heavy fabric and that added protection can thus be achieved without increasing the garment weight.

"Through investigations with the rain tester it has been further found that the rain penetration through the outer layer of cloth is surprisingly dependent on the type of lining fabric used. Less rain gets through the outer layer if the inner one is of a resilient material, such as a light flannel, than if it is a thin, non-resilient fabric. The springy lining seems to cushion the blow of the rain drops, so there is less tendency for them to penetrate the outer fabric. The protective qualities of the garment can be even further increased by applying a water repellent to the lining."

POST-WAR GAS

Will be a Versatile Fuel, High in Octane Rating

POST-WAR airplanes may be designed to use the same gasoline as post-war automobiles, Thomas H. Risk, refinery technologist of Ethyl Corporation, predicts in a survey of factors affecting the anti-knock performance of peace-time

tane number of 85 to 88 will make this dual function possible, Mr Risk says.

Such gasoline will be comparable in anti-knock quality to the 87-octane aviation gasoline sold prior to the war. Hence it is conceivable that many of the post-war planes, estimated at 500,000 by 1950, will be designed to use premium grade motor fuel rather than a special aviation gasoline, the survey points out.

Values of 85-octane number for premium fuel and 79-octane number for regular fuel are indicated for as early as next year, should the war end that soon. Refinery equipment now under construction will have been completed by 1945 and therefore available for peace-time production of gasoline.

Owing to tremendous advances in refining technology during the war and to other important factors, laboratory-determined octane numbers alone (such as the American Society for Testing Materials figures quoted here) will not tell the full story of anti-knock quality of post-war fuels, it is declared. New characteristics derived from improved refining processes and new blending stocks will result in better performance than even the higher post-war octane numbers indicate, Mr. Risk explains.

"Besides octane number, the chemical composition of the fuel, the engine that will use the fuel, and the type of transmission used in the vehicle, all will affect the anti-knock quality of the gasoline on the road. Yet, laboratory octane number is the only yard-stick we have at present with which to estimate the post-war anti-knock quality of gasoline, because there are, of course, no post-war cars in which to test the new fuels.

"Post-war prosperity, or the lack of it, will affect public demands for gasoline quality," Mr. Risk continues. "Other factors that must be considered include the probable condition of engines in older cars and the anti-knock requirements of new cars. Therefore, because of post-war uncertainties, the amount of premium grade gasoline sold may be anywhere between 10 and 20 percent of the total production."

Aviation fuel after the war is expected to account for 6 to 8 percent of all gasoline produced as compared to only 1 to 2 percent in pre-war days This is approximately a four-fold increase, and reflects the effects of wartime expansion on future aviation gasoline demands.

Capacity to produce aviation fuel will greatly exceed the forecasted peacetime demands by the time the war is over, says Mr. Risk in discussing what is likely to happen to new refinery equipment when the war ends.

"Conceivably the petroleum industry could continue to produce 100-octane gasoline up to the full limit of capacity and dump the excess into motor gasolines. To determine the effect of this procedure, an estimate of post-war aviation gasoline consumption is required. Estimates of this demand vary considerably from about 50,000 barrels a day to 150,000 barrels a day.

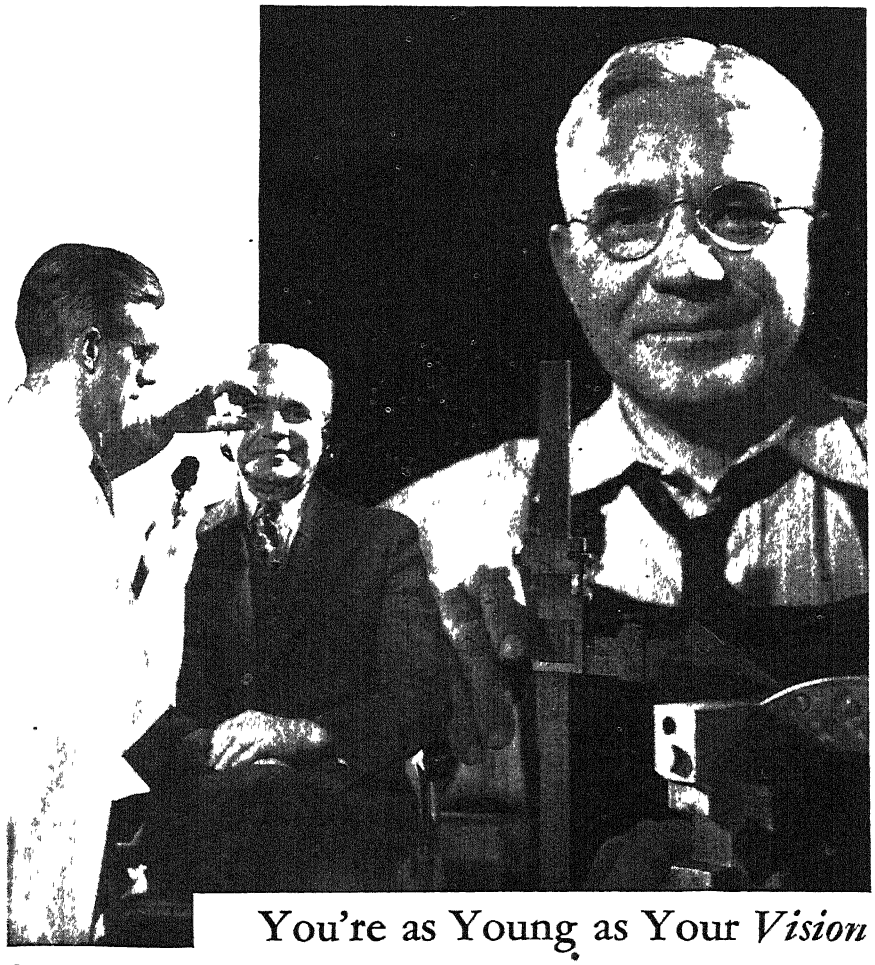
"Due to wartime restrictions, the excess cannot be stated in actual figures, excess post-war aviation gasolines were used in this manner, the over-all effect would be a two to three octane-number increase in motor-gasoline octane number. This relatively slight increase in octane number would be expensive since aviation gasoline costs the refiner considerably more to make than motor gasoline.

"It is, therefore, much more likely that new refinery equipment not needed to make aviation gasoline after the war will be used more directly to produce gasoline suitable for automobiles, trucks, and buses. The exact manner of utilization will vary within the industry and will be based on such factors as relative demand for various ium, housebrand, and third grades, general refinery economics, that is, equipment available, crude supplies, and so on; and post-war car requirements and comparative demands."

FLUORESCENT LAMPS

Will be Made in New Forms Post-War

DESIGNED to meet the lighting needs of the post-war era, two entirely different shapes of fluorescent lamps, one circular to fit inside the shades of floor and table lamps, the other a long, slender tube only three quarters of an inch thick, will be manufactured as soon as



You're as Young as Your *Vision*

Of course, eyes cannot actually be made younger, even under modern scientific care. But usually they can be given again the keen, comfortable vision they enjoyed years ago. That is important to veteran craftsmen now called on for long hours in the service of their country. It is important to you, in your work, for your future.

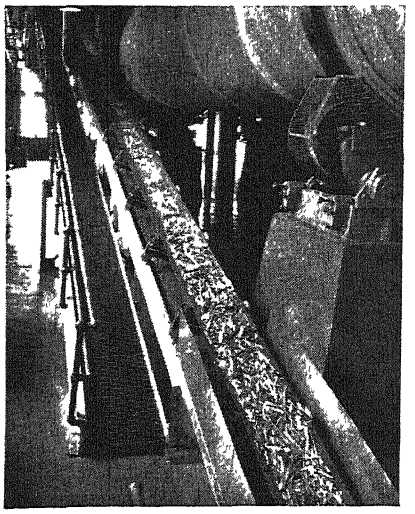
Not many people realize the great advances made in conserving human vision during the past few years. And not many know, either, the high precision of modern eye examination or the visual comfort and keenness that professional skill is able to restore. If you have the slightest suspicion that your eyes need attention, see that they get it—promptly. Glasses may not be necessary.

Whether glasses are needed or NOT, neglect cannot help. The only help available to you is the professional and technical skill of the ophthalmologists, optometrists and opticians in your community who have made a lifework of visual care. They know what can happen to your vision. You don't. Better consult one of them today.

BAUSCH & LOMB

OPTICAL CO., ROCHESTER, N.Y.

Makers of Optical Glass and a Complete Line of Optical Instruments for Military Use, Education, Research, Industry and Eyesight Correction and Conservation



Wood chips are carried to the distillation retort on a conveyor belt

war conditions permit, the Westinghouse Lamp Division announced recently.

The circular lamps will be used in the home for portable lamps and in many types of ceiling and wall fixtures throughout the house. They could be used either alone or in combination with ordinary types of incandescent lamps.

While the new long, slender fluorescent lamp may also be used in the home, its chief advantage will be in advertising display and show-case lighting and for locations where long lines of continuous light are needed to harmonize with an architectural design. Because of its additional length—three feet longer than the largest fluorescent lamp now made by Westinghouse—it will be better adapted to many specialized types of lighting than the more usual size of fluorescent lamp.

WOOD DISTILLATION

Carried on at High Temperature

To Obtain Greater Yield

A wood distillation process introduced on a commercial scale by Henry Ford 20 years ago is today providing the United Nations with quantities of badly needed chemicals. Known as the Ford-Stafford process, it is employed at the wood distillation plant located at Iron Mountain, Michigan.

Operating on a 24-hour basis, the plant is producing such vital war-time chemicals as ethyl acetate, a solvent used in quick-drying lacquers for trucks, tanks, jeeps, and other war vehicles; denaturing grade methanol used for making denatured alcohol; chemically pure menthanol, quantities of which are used in making plastics; and methyl acetone and acetate, solvents used in war plants.

Originally most of these chemicals were regarded as by-products, with the production of charcoal being the real objective. The demands of wartime industries, however, have altered the picture until the chemicals are as important as the charcoal.

In the usual type of distillation plants an intermittent process is used whereby cord wood up to six inches in diameter is placed on small cars and trundled into horizontal ovens The walls are then heated, and as the wood slowly carbonizes the resultant vapors are drawn off It is from these vapors that the various by-products are obtained.

Under this older process, temperatures must be limited to around 600 degrees to prevent damage to the equipment. Time also is lost in loading and unloading the retorts.

The Ford-Stafford continuous process utilizes a vertical, thick-walled retort about 40 feet high. The wood is chipped by running it through a grinder, then is fed into the top of the retort. The retort is heated to 1000 degrees. The released vapors create an exothermic reaction which maintains the 1000 degree temperature.

Charcoal, drawn off at the bottom of the retort, is compressed into briquettes, while chemical-producing vapors are drawn off from the top through condensers. Wood chips are added, as required, to maintain a level seven feet from the top of the retort

The maintenance of higher temperatures not only produces better charcoal by extracting more volatiles, but yields a greater volume of chemicals per ton of wood.

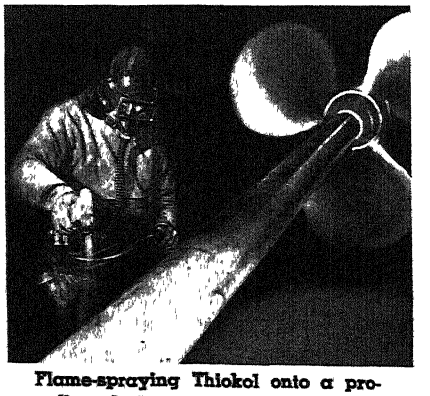
RUBBER COATING

Protects Propeller Shafts

From Electrolytic Action

A successful solution to the menace of destructive electrolytic action, which eats away the propeller shafts of Navy subchasers, minesweepers, and other wooden vessels, has been found to be synthetic rubber flame-sprayed onto steel propeller shafts by a new process, according to the Schori Process Corporation. Heretofore, bronze propellers fitted to steel shafts on wooden vessels produced an electrolytic action through the union of two dissimilar metals in salt water, with the result that the shaft is so eaten away within a few months that it cannot stand up under the high-speed operation.

After nearly a year of experimenting with flame-sprayed plastics, which all proved too brittle and could not be easily ground for spray-gun operation, Schori engineers found that Thiokol synthetic rubber could be sprayed on the shaft while in position on the ship. The molten rubber hardens rapidly to form a firmly bonded coating with an extremely high abrasion re... Since the shaft is completely protected from contact with the sea water, there is no opportunity for corrosion or pitting to set in.



Flame-spraying Thiokol onto a propeller shaft to prevent electrolysis

This same coating can also be used advantageously to coat the interior of bronze valves on salt-water pipelines, low temperature condenser plates, and other inaccessible but vulnerable underwater portions of steel vessels, it is stated.

TRANSPARENT TUBING

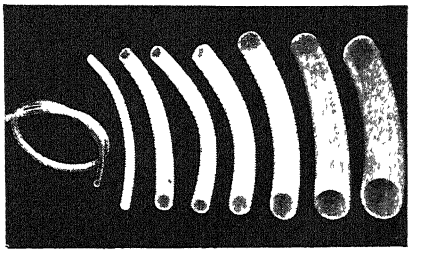
Resists Solvents, Has Many

Industrial Applications

Solvent-proof, rubber-like, transparent tubing, made of compar, a type of vinyl resin developed by Resistoflex Corporation, is finding a number of uses in aircraft and other industries.

In the laboratory, its transparency permits constant inspection of the contents. Because the tubing is tough, strong, and inert to almost all organic solvents it is highly useful for low-pressure, room-temperature handling of these hard-to-handle materials. It is not affected by even such active solvents as carbon disulfide, carbon tetrachloride, trichlorethylene, perchlorethylene, acetylene tetrachloride, benzol, and toluol, or by oils and fuels such as high-octane gasoline with the highest aromatic content.

Having the lowest permeability to gases of all natural and synthetic rubber-like materials and being unaffected by such gases as freon, methyl chloride, methyl bromide, phosgene, mustard,



Transparent, solvent-proof, rubber-like

propane, butane, and water gas, further applications for compar tubing are immediately apparent. When used on Bunsen burners or other laboratory appliances the tubing does not absorb the protective odors with which illuminating gases are usually loaded and, therefore, prevents the laboratory atmosphere from being contaminated by them.

One of the many interesting applications which has been developed recently and for which transparent compar tubing has been used with greatest success in the aircraft industry, is as temporary instrument lines for test flights Filled with mercury, its transparency permits taking moving picture records of the fluid movements during test flights, thereby making possible an accurate check of the flight instruments. Another application for which the translucent tubing has proved well adapted is as a cover for conveyor hooks passing through degreasing operations.

While transparent compar laboratory

tubing is extremely tough and strong it is not generally recommended for industrial applications which now employ fabric reinforced hose constructions containing tubes or cores of other compar formulations Resistoflex hose and hose assemblies, using compar, are widely employed for aircraft instrument and hydraulic lines, fuel and oil lines on industrial machinery

HOT PROPS

Ice Formation Prevented By Heated "Skin"

One of the most persistent enemies of safe flying—formation of ice on propellers of planes in flight—is now being overcome by a new electrically heated propeller "skin," made in part of a special conductive synthetic rubber, that enables the propeller surface to warm up like a sick-bed heating pad.

The new heated propellers, to which dangerous "ice in the sky" cannot cling, were developed in conjunction with the National Advisory Committee for Aeronautics and are now, following tests, being installed on planes destined for icy-region operation, it is announced by The B. F. Goodrich Company.

The "skin" is made of a combination of two kinds of synthetic rubber, the outer surface being a thin coating that is tailor-made to conduct electricity instead of blocking its flow

Since the current comes from a generator attached to the shaft, the propeller can be kept warm and ice-free as long as the engine is running. When there is no danger of icing, no current is passed through the skin. It simply rides the propeller, cemented permanently in place and conforming exactly to its shape so as not to interfere with aerodynamic design or performance.

ELECTRICAL CHALLENGE

Many Things Yet Unlearned About Utilization of Electricity

A fuller utilization of the more than 80 "octaves" of the ether spectrum offers perhaps the greatest promise of bringing a fuller, healthier, and longer life to mankind in the postwar era, according to Samuel G. Hibben, noted lighting authority and director of applied lighting for the Westinghouse Lamp Division.

"When we speak of an 'octave' in the ether spectrum," Mr. Hibben explains, "we are using a term that denotes an electrical frequency twice as great as some other frequency, just as in music, when a note has twice the frequency of another, we speak of it as being an octave above it in pitch.

"In one limited region of the light spectrum, comprising about three 'octaves' of electrical radiation," Mr. Hibben declares, "we have achieved particularly interesting developments. Expressed in terms of angstrom units, the unit of measurement by which we denote the length of light waves, the radiations within this span of three 'octaves' range all the way from 2000 to approximately 16,000 angstrom units.

"That is the limited span in which all the outstanding lighting progress we have made has been achieved. But there still remain some 77 'octaves' of light radiations—more than 25 times the 'territory' we have so far covered—about which we know very little and which offer a fertile field for research

"Within the present explored range there are many outstanding developments. One of these is the infra-red heat lamp, now filling many industrial heating and drying needs in the nation's war plants. This lamp seems destined to become a popular device in the home and on the farm, not only for supplementary spot heating, but also for animal husbandry, regulation of plant growth, and humidity control.

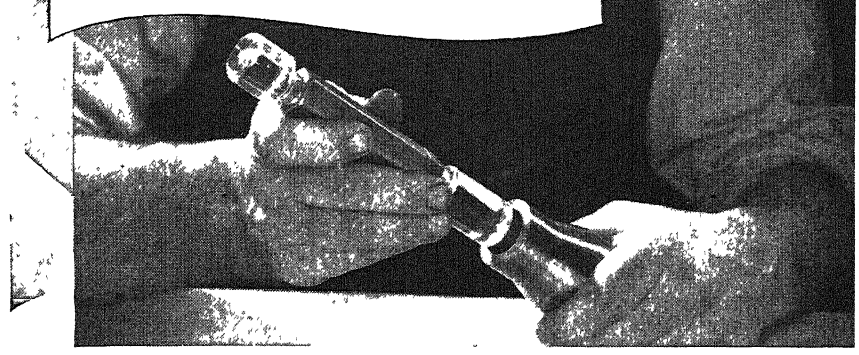
"In this same range, also," he continues, "is the high efficiency mercury vapor lamp which has proved such a valuable aid in the lighting of large industrial areas and for supplying powerful searchlight projection

"In the near-ultra-violet region, we have discovered that sources of electrical energy can be used to produce 'black light' for the excitation of fluorescent dyed materials such as carpets and upholstery fabrics, to aid crime detection, and for food and drug analyses

"Delving further into the ultra-violet region," Mr. Hibben reports, "we find an increasing interest in radiations used to reproduce anti-rachitic sunshine, or for general health maintenance, while still further down the scale we find perhaps the most important tool of all, the ultra-violet lamp which is used to kill

Ingenious New Technical Methods

Presented in the hope that they will prove interesting and useful to you.



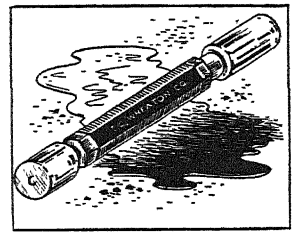
Precision Ground Glass Gages Afford Visibility in Inspection

In the hands of the skilled mechanic, glass gages bring an important plus function to precision gages. It not only checks the new tool's size, but gives the inspector an idea of what kind of surface to expect from that particular tool. The visibility permitted by the glass gage allows the inspector to see the surface in blind holes as well as through holes

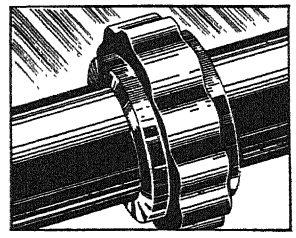
Some of the apparent advantages of the glass gage follow. Glass gages afford visibility in inspection. Glass gages are not subject to corrosion There is less tendency to gall in some applications Sense of feel is more pronounced when using glass gages Because the thermal conductivity of glass is less than steel, body heat of inspectors will not be transmitted so rapidly to the gage to affect gaging dimensions.

Chewing gum, too, is really useful and helpful in these tense times to people who are working on the production front making material for our war effort But, our Armed Forces have been constantly increasing their demands for Wrigley's Spearmint, Doublemint and Juicy Fruit. It is only natural that we and you both feel that the needs of our fighting men and women come first.

You can get complete information from Industrial Glassware Division of the T. C Wheaton Co , Millville, N. J.

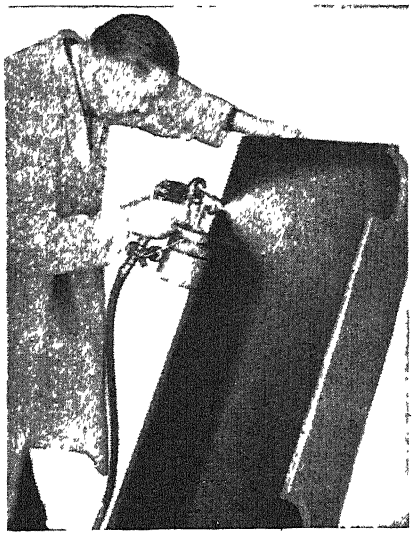


Glass gages are not subject to corrosion or rust



Visual inspection of surface coincident with inspection for size.

Y-113



Spraying an adhesive sound deadener on the interior surface of a metal housing. Right: A number of pliable adhesives have been developed for bonding a wide range of materials, both porous and non-porous

pathogenic bacteria and spores of the mold-forming fungi. This device gives promise of controlling many types of infectious diseases and should prove a valuable tool in the field of air conditioning.

"Since we all hope to do tomorrow's jobs better than we have in the past," Mr. Hibben emphasizes, "it is gratifying to realize the scientific progress we have made to date. However, many 'unknowns' await the future scientist and we must not be complacent about what we have accomplished when so much still remains to be done

"For example, we would like to know how to obtain 100 lumens per watt, or one sixth the possible efficiency from a light source; how to obtain two colors from the same electrical discharge in a gas or vapor; how to develop indoor sunshine for a vegetable garden in the basement and for comfortable seeing in the factory. These and many other scientific problems await our solutions Herein lies the challenge to our scientists of the future."

ADHESIVES

Do More than Bond

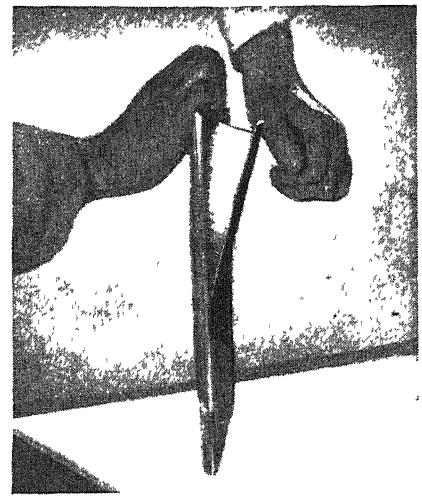
Materials Together

One of the significant trends in industry, under the impetus of war production, has been the increase in the use of adhesives This development refers to pliable adhesives for bonding materials together—impervious materials such as metal to glass, formica, Masonite, and metal to metal; materials of impervious and porous natures such as metal to leather; and two porous surfaces such as leather to wood.

Varying uses require different types of adhesives. Thus, for example, more than seven hundred types of industrial adhesives have been developed in the laboratories of the Minnesota Mining and Manufacturing Company. Before the outbreak of the war and the sudden widening of adhesive horizons which followed, the automotive industry was the largest and most consistent user of industrial adhesives

Adhesives have numerous other uses than that of bonding materials together. Sealers, for example, have been developed to meet special war production requirements, such as sealing riveted joints in airplane gas tanks, sealing plane pressure cabins, sealing naval gasoline storage tanks. and a variety of related uses.

So many problems have been solved



easily and inexpensively with sealing compounds that if there is anything certain about post-war industry it is that it will depend heavily on the time- and money-saving properties of this type of adhesive

Another type of adhesive with an assured future in post-war industry is used for coating purposes. During the last three years, with the war industries practically cornering the supply of metals, the only hope many industries had of carrying on at all was to find suitable substitutes. In this field adhesive coatings have proved to be veritable life savers. They have proved efficient as protective linings in pickling and plating vats, in heater tubes, and as protection against the corrosive action of exhaust gases. Another large use of this type of adhesive is for coating the underbodies of automobiles, trucks, and passenger coaches on railroads as a protection against abrasion, rust, and corrosion.

Adhesive coatings can be applied by brushing, dipping, or spraying. The most efficient method of application is determined by the shape and size of the object and the type of compound used. Insulation against heat, cold, and noise for post-war automobiles, buses, railroad coaches, and airliners, will be much simpler and more economically applied in those post-war days which seem to hold so much promise for American industry.

NEW RESINS

Now Available, Offer Wide

Range of Characteristics

The name "Geon" has been chosen for a group of unique polyvinyl resins which are now available to industrial users. Geon, from the root word geo (the earth) was selected because the basic raw materials from which these polymers are derived have mineral origin, according to The B. F Goodrich Company.

Coating of fabrics, paper, foil, and other materials, insulation of wire, manufacture of film for packaging, and the manufacture of extruded and molded products are among the principal fields for Geon resins. Purchases of any of the resins are subject to allocation by the War Production Board under General Preference Order M-10, under which the polyvinyls are allocated, although reasonable quantities are available for experimental purposes.

Two chemical types are offered currently. The Geon 100 series are special vinyl chloride polymers characterized by their thermal and light stability, toughness, and chemical inertness. The Geon 200 series was created to meet the need for polyvinyls which combine increased solubility and thermoplasticity with exceptional stability, chemical resistance, and wide useful temperature range. Their resistance to hydrolysis by boiling water or even hot alkali is outstanding in the field of vinyl chloride copolymers, and like the Geon 100 series they have unusual stability to light and heat.

When compounded with other materials, Geon resins can be processed in many ways, including injection and compression molding, extruding, calendering, and solution coating.

Compositions varying from the rigid thermoplastic to a very soft jelly can be obtained by modifying the Geon resins with other materials. Each composition exhibits to a high degree the many desirable characteristics of the base resin used.

Tailor-made formulations can be supplied for special purposes. It is pointed out that, because these materials can be varied so widely in useful properties, it is greatly to the advantage of the prospective user to consult the manufacturer in choosing a compound formulated to fit a specific need

TOMORROW'S AIRPORTS

Must be Planned Now

For Many Purposes

Airport planning is the lazy giant of post-war aviation that must be put to work immediately if the vast potentials of commercial and private flying are to be attained, according to C. Bedell Monro, President of Pennsylvania-Central Airlines.

"The two undeveloped wings of aviation planning now are airport development and private flying," says Mr. Monro, "and among the major tasks of the entire aircraft industry are the development of programs to meet the needs in these two fields.

"PCA has been studying methods of helping the private flier, and we feel that the airlines, with their huge maintenance base facilities, their know-how, their experience in aircraft upkeep, and their other facilities such as weather forecasting and dispatch procedures should provide concrete and reasonable

access to these facilities for the private flier, especially during the period after the war when these facilities will not be readily available in many places.

"But this will not be enough," continued Mr. Monro, "unless airports are blueprinted today to handle a minimum amount of air traffic. Even the most conservative estimates mean that immediately after the war the airports of this nation will have to handle at least three or four times the volume of plane traffic handled before the war. Many American cities will be left grounded and many Americans will be denied the full benefits of air transportation for several years unless the blueprints are drawn today.

"Airports cannot be built overnight, in weeks, or even in months. And even though we have acquired hundreds of new fields during the war, many of them are not so situated as to be available for use by cities Many have been engineered for war and not for peace Many are off the beaten track, and civic airports can only be brought into being after periods of planning and even longer periods of construction.

"There are some enterprising and far-sighted American cities that are not only studying and planning their airport needs, but which will be ready to meet the advance of the air age. But for every such prepared city there are hundreds of unprepared communities where inertia will lose for them the full benefits of the air tomorrow

"Not only are airports essential for the business life of a city, but they can play a major role in providing jobs for the several million men in the Air Forces, many of whom will be looking to aviation for employment when they return home. For many, it is their only vocation, and our responsibility to them is staggering It can only be met if we here at home prepare now, with what we have, to provide jobs for them when they return.

"Cities must study the whole encompassing picture of tomorrow's aviation—it is not enough to build large airports solely for commercial operations. Hundreds and thousands of persons will want facilities for private flying. These facilities will mean business and progress. They will mean a strong and safe America, for it is only through the development of millions of flying youth that the nation can remain in the forefront of the flying race—and to lag in that race will mean doom in the world of tomorrow."

GERM KILLING

Can be Accomplished in Air-Conditioning Plants

UTILIZATION of air-conditioning plants in motion picture theaters, schools, and other public gathering places, to "reduce the menace of airborne infection" through "sterilization and purification of air supplies by ultra-violet light" is urged by G. Morley-Davies, District Health Officer, Bristol (England) Public Health Department, in a scientific paper published in the British magazine *Municipal Engineering*.

"Now that excellent air-conditioning plants are available and have been installed in so many large and commodious public halls and meeting places, it is time someone gave a modicum of thought to the important matter of sterilizing and purifying the air after it has passed through the usual mechanical processes, whereby it is washed, warmed, or cooled and is on its way into the auditorium," Mr. Morley-Davies states.

"Recent research in the world of electricity has brought into use the ultra-violet rays of light, and shown their amazing powers where sterilization is concerned These ultra-violet lamps, when in action, can kill almost all bacteria that come within a range which can be quite large in its extent The ultra-violet lamps so far developed have demonstrated their high efficiency and it has been shown that their effect on germ life is devastating. Experts have shown, through the microscope, many colonies of disease germs floating about in enclosed air, suddenly rendered completely inactive when the ultra-violet lamps have been brought into action against them.

"Germicidal lamps are definitely going to find a place in air conditioning some time in the future. It is not sufficient to wash the air going into a building; it will have to be thoroughly filtered and treated germicidally as well. It is known in medical circles that blacked-out atmospheres incubate and spread disease germs quicker than any other. The cinema must come under suspicion in this connection. Few cinemas can be flooded with sunlight during the morning, and it is well known that sunlight is one agent that keeps national illness and disease down to its present satisfactory level. Where sunlight cannot enter, then disease germs will thrive and flourish.

"It is my opinion that in the not so far distant future every cinema auditorium will be fitted with several of these ultra-violet lamps, suitably arranged to flood the whole of the atmosphere inside the theater with health-giving ultra-violet light. This is not visible light, of course, and it will not affect the requisite darkness of the auditorium. I have not yet heard of this being done anywhere, not even in

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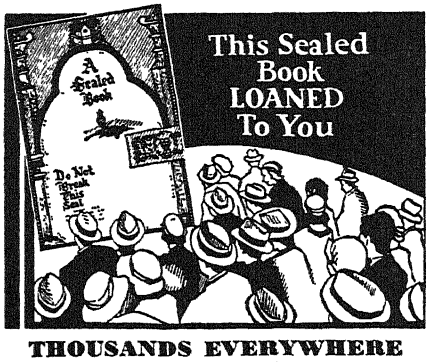

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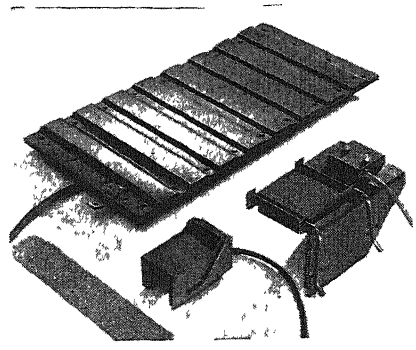

Types of electric contact heaters

America, but I think it will come sooner or later.

"Infectious epidemics such as influenza and the common cold, which are the bane of public health authorities, are helped considerably to advance their evil hold on a community by the crowding together of people in stuffy atmospheres Modern air conditioning has done noble service in removing the 'stuffiness" from our theaters and entertainment halls, but more will have to be done. Indeed, it would appear that public health authorities must yet learn to realize that there can be a tremendous advantage in getting a crowd of pople into an enclosed building such as a theater. They can there be given treatment through the aegis of air that would not be possible by individual methods! If the air can be charged with a safe germicide—ultraviolet light is a safe germicide—then the benefit to the health of the people subject to this treatment would be far-reaching. The risk of epidemics could be blotted out by such large-scale dosage and control."

ELECTRICAL HEATING

Made More Efficient By New Design

UNTIL now a military secret, an advance in electric contact heating involves a process which is serving a wide range of uses, principal among them being the heating of the bolt or firing mechanism on machine guns, of the hydraulic actuating mechanisms on airplanes in the stratosphere, and of storage batteries in army tanks in below-zero theaters of war.

Since the new heaters attain a high degree of efficiency, it is expected that they will be adapted to a multitude of peace-time uses, for they can be made in nearly any size, contour, and capacity. They have the advantages of light weight, of operating at low wattage, of being safe in the presence of explosive vapors, of operating without deterioration of the heating element, of withstanding severe vibration, and of maintaining exact temperatures within close limits. The efficiency of one unit, as an example, may be judged by the fact that, even with outside temperatures as low as 65 degrees below zero, Fahrenheit, it will raise the temperature of a machine gun mechanism to well above the desired operating temperature.

A combination of several factors accounts for the efficiency of the principle developed by the H. and A Manufacturing Company. Despite the low current consumption, which ranges from 35 watts to 400 watts in the various sizes and shapes of units so far developed, thermal losses are so well controlled and heat transfer so efficiently accomplished that a unit weighing only a few ounces will raise the temperature of 30-odd pounds of steel 90 degrees above sub-zero external temperatures. This is partly due to the methods of insulating and housing the heating element and partly to the method of attaching the heater to the object to be heated. By this method, the fact of the heating plate is held in compressive, resilient contact against the surface through which the heat is to be transferred. No nuts or bolts or permanent attachments ordinarily are required; the units in most cases can be "sprung" onto the object. While they can readily be removed, their "grip" withstands the severest vibration.

FOOD DEHYDRATION

Requires Application of Engineering Skill

THE rapidly expanding field of food dehydration can no longer be handled by haphazard, makeshift methods, but is a scientific problem evolved in the past 15 years and requires the application of engineering knowledge and techniques, said W. R. Marshall, Jr, of the Experimental Station of the E. I. du Pont de Nemours and Company, in a recent address before the Metropolitan Section of the American Society of Mechanical Engineers, New York.

"Because the scale of production of dried foods is so large," said Mr. Marshall, "engineering is imperative in designing, building, and operating the large pieces of drying equipment required.

"Although the problem of removing moisture from solid materials has been encountered by man through the ages, nevertheless the underlying principles involved in effecting this removal have been studied scientifically only during the past 15 years. The reason for the delay in the development of drying as a science is the fact that quantitative information on drying processes was not required before the advent of our present large-scale industrial chemical plants which involve drying as an important unit operation.

"Thus, when the need of removing tons of water an hour arises, the problem is no longer a simple matter of drying in any space which happens to be available, but one of engineering proportions in which the well-established thermal and thermodynamic properties of air-water vapor mixtures are required, together with exact information on rates of heat and mass transfer for various conditions of drying. It is apparent, therefore, that the operation of drying logically falls in the realm of the engineer trained in the fundamentals of heat and mass transfer and the broad field of heating and air conditioning.

"A development of a drying theory may be pursued along two lines. One

approach may be termed the 'internal method,' which is a fundamental viewpoint and concerns the exact manner in which a liquid moves through a given solid during drying. The other approach is the 'external method' and is more empirical in that the drying characteristics of a solid are interpreted in terms of the effect of the external drying conditions of air temperature, air velocity, and air humidity.

"All the developments and methods used to study the drying of non-food materials have application in the present rapidly expanding field of food dehydration. Since the drying of foods involves the use of thermal means for its consummation, problems of heat transfer are encountered. Likewise, the removal of moisture involves transfer of liquids and vapors and thus permits the application of concepts developed in the field of mass transfer. The special problems which food dehydration brings to the field of drying are those of maintaining high food value in the dried product, retention of characteristic taste and odor, and imparting keeping or preservation properties to the dried food for purposes of storage and shipping."

MORE CHICKENS QUICKER

Made Possible Through Use of Ultra-Violet

A YEAR-LONG study in 400 chicken, duck, and turkey hatcheries and feeding stations has demonstrated that electrically produced ultra-violet rays reduce poultry mortality as much as 68 percent, according to Dr. Harvey C. Rentschler, director of the Westinghouse Lamp Division Research Laboratories.

Stressing the fact that reducing the mortality of both baby chicks and mature birds is of special importance at this time because of the meat shortage, Dr. Rentschler says:

"Sixty percent of chick mortality occurs within the first 16 days. Germ-killing rays of short-wave ultra-violet are helping to reduce these losses. In addition, the small amount of vitamin-D wavelengths generated by bactericidal lamps steps up the growing time of young birds—an important factor today when feed is scarce.

"To a poultryman, time is money in the most literal sense of the word—a bird grown in five weeks instead of eight puts the price of two and one quarter pounds of feed in the poultryman's pocket and a more reasonable chicken dinner on the nation's tables," Dr. Rentschler points out.

In a carefully controlled test of two battery brooding houses, identical except that one contained the bactericidal ultra-violet lamps called Sterilamps, Rucker's Imperial Breeding Farm and Hatchery, Ottumwa, Iowa, reported 68 percent lower mortality and 50 percent fewer culls and runts—or discards—in the house employing the lamps. Birds in the irradiated unit grew to range size in five weeks, compared with eight weeks for the unirradiated birds. The test involved 11,000 chickens.

Many diseases of fowls are of a respiratory nature and the infectious organisms are carried by the air. Continual disinfection of the air through bactericidal irradiation reduces the contamination below the level at which it might become epidemic. At the same time, short-wave ultra-violet destroys mold and fungus that can be responsible for such diseases as mycosis and brooder pneumonia.

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SUGAR SCIENCE

To be Studied in Co-operative Plan

A LONG-RANGE program of research on sugar, the most familiar and yet one of the least understood scientifically of all the products of nature, is underway at the Massachusetts Institute of Technology in co-operation with the newly established Sugar Research Foundation of New York. Announcement of this work was made recently by Dr. Karl T. Compton, president of the Institute, and Joseph F. Abbott, president of the Sugar Research Foundation. The foundation was created for the development of fundamental knowledge in the field of carbohydrate chemistry, biochemistry, and nutrition. Membership is open to all producers and processors of sugar in this country, Puerto Rico, Hawaii, and Cuba.

It is anticipated that the chemical studies conducted under the arrangement will not only extend knowledge of the role of sugar and other carbohydrates in the human body, but also will

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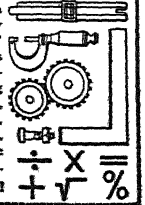

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Acid-proof mortar being poured in a joint in a pipe line for disposal of acid waste from an industrial plant

unfold wholly new industrial uses for sugar and its derivatives. An important stated objective of this broad research program will be the training of scientists in the field of carbohydrate chemistry to prepare them for service in the industry for further technical studies Provision has also been made for fellowships for young graduate students who are candidates for advanced degrees to permit them to continue their work in this promising field.

Sugar, whether from cane or beet, is one of the purest chemical substances known to man and is produced in enormous quantities at relatively low cost As an inexpensive source material, its chemical conversion to substances which can be utilized for other purposes than as a food is an interesting scientific challenge which demands the most advanced investigation

ACID-PROOF MORTAR

Saves Steel and Natural Rubber

MADE of sulfur plasticized with synthetic rubber, acid-proof mortar is saving thousands of pounds of precious steel and natural rubber in the construction of pickling tanks, acid-proof floors, chemical vats, and industrial sewers for the disposal of used acids and other wastes.

Manufactured under the trade name "Tegul-Vitrobond," by The Atlas Mineral Products Company, this Thiokol-sulfur cement is reported to be stronger than the best concrete available and has many other interesting characteristics which ably fit it for its war-time job. For example, it is inert at temperatures up to 200 degrees, Fahrenheit, and is unaffected by hot or cold acid, by corrosive salt or mild alkaline solutions, has a bond to brick of from 400 to 500 pounds per square inch, and is imprevious to penetration by liquids. It is also able to withstand severe trucking abrasion and mechanical punishment. Equipment built with it is said to be virtually impervious to wear.

Through processing a type of synthetic rubber developed for this cement with sulfur, and adding other ingredients, a comprehensive series of Tegul-Vitrobond cements has been developed to meet numerous industrial applications requiring compounds of different properties. These mortars are particularly suited for chemical process equipment for the production of chemicals, explosives, pigments, and rayon.

Perhaps the greatest saving of steel effected by this sulfur-Thiokol cement is in the substitution of concrete vats lined with acid-proof brick joined with the cement for steel tanks.

Of major importance in acid-proof brick construction is the method of taking care of contraction and expansion when the tank is in service This is accomplished by placing an acid-proof and acid-tight expansion joint in the brickwork at varying intervals, depending on the size, shape, and operating temperature of the tank. This joint is built up by cementing a series of horizontal and vertical, soft, unvulcanized rubber plates to their adjoining brick surfaces in such a manner as to displace a given volume which would otherwise be filled with Tegul-Vitrobond The completed expansion joint cuts the joined brickwork into separate sections which are bonded by an acid-proof and acid-tight rubber connection

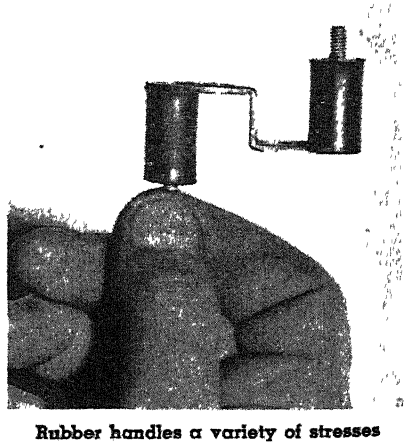
Tegul-Vitrobond is heated in iron kettles over a wood or gas flame. When the material reaches the correct temperature, it is ladled into the joints between the brick. Horizontal joints in the brickwork are made by placing ¼-inch chips of Vitrobond beneath the brick. When the molten mortar is poured into the joints, it flows against the form work and upon solidification seals every joint, as well as impregnating the brick

The versatile Thiokol-sulfur cement also has high utility in the construction of acid-proof floors. When molten cement is poured between tiles, the resulting floor is durable, attractive, and acid-proof. Such construction is being widely used in industrial chemical plants, dairies, and food plants

RESILIENT MOUNTING

Permits Flexible Designs in Many Fields

A PATENT on an entirely new type of resilient mounting utilizing rubber or rubber-like materials has been granted



Rubber handles a variety of stresses

to Herbert H Fink, engineer of The B F. Goodrich Company Mountings covered by the new invention have cushioning cylinders interconnected by arms in S-fashion. This arrangement permits an extremely soft suspension under light load and allows the resilient material freedom of movement in all directions.

Handling of a variety of stresses including shear, bending, torsional, or twisting is accomplished by the mounting, which also permits the material to be stressed simultaneously under both shear and tension.

Various arrangements of the rubber cylinders and the arms to which they are attached will change the rate of deflection of the new mountings in any direction.

The invention is valuable in a variety of applications, including the mounting of housings for aircraft compasses and other instruments, motors for musical instruments, including those of the coin-operated type, flexible power transmission couplings, and in other fields where structures are mounted resiliently.

The degree of movement permitted by the cylindrical resilient bodies of the new mountings by the stresses in torsion, shear, bending, and compression allows action in any direction to be controlled by the way in which the mounting or groups of them are installed

THIRTY HORSEPOWER

Delivered by Motor

Weighing Only 57 Pounds

THE streamlined projectile-like contraption which George Pfau, General Electric tool maker, is shown assembling in the accompanying illustration may look like a new secret bomb, but actually it's a new "tailor-made" motor destined to help make our bombers more effective. One of several models now being built, this small motor will serve as the "engine" driving the propellor of a small model plane operated in a large wind tunnel under conditions equivalent to those of actual flight.

This motor is only 5 inches in diameter and 13 inches long, yet it has a rating of 30 horsepower. It weighs only 57 pounds and while its rated speed is 6000 revolutions per minute it can operate in excess of 7000 revolutions per minute. It is water cooled.

The small parts to the right of the motor comprise the tachometer assembly for determining its speed. This assembly fits into the front end of the motor.

Despite its small size, this new electric motor has high power rating

WHITEST OF WHITES

Titanium Dioxide Does a Number of Industrial Jobs

FROM one of the blackest of black substances, ilmenite, comes the whitest of whites, which is also the ninth commonest element in the earth's crust. Between breakfast and bedtime everyone is sure to handle at least one object containing this substance—which is titanium.

Although titanium is an important ingredient in such everyday things as fabrics, linoleum, refrigerator enamels, paper, and white paint, as recently as World War I it had scarcely any commercial value and even today is chemically among the lesser known elements. Yet among the thousands of chemical compounds manufactured by Du Pont, it is one of the most versatile

Titanium dioxide is a white powder, so fine that 16 million individual particles of it side by side would measure only one inch long.

It is used by the armed forces in the protective creams that safeguard skin against painful flashburns inside gun turrets, and in other creams that offer protection against sunburn and insects in the tropics.

This same titanium dioxide, as an ingredient of the coating for welding rods, assists in maintaining a steadier arc and in improving the weld.

It is titanium dioxide which gives present-day white paints their extraordinary whiteness and hiding power, and the lighter colors their clarity and resistance to fading. Many peacetime products such as white rubber and the best white leather depend for their whiteness on titanium dioxide. White buckskin, for example, is pigmented in the tanning operation with titanium which is so fine that the particles go all the way through.

Linoleum and felt-base floor coverings owe much of their resiliency and long wear to this compound. It reaches the consumer in coated fabrics, even in soap.

Titanium dioxide is handling a job in the field of paper manufacture that affects all of us at the present time. Wartime needs for paper are so great that the Government asks for waste paper as salvage. Books and magazines are printed on thinner paper. Even the writing paper you buy today is thinner.

A few years ago it would have been difficult or impossible to use such thin paper, because the print or writing would have "shown through" from the back. But titanium dioxide, added to paper, keeps this from happening and so, conserves paper—makes it go further.

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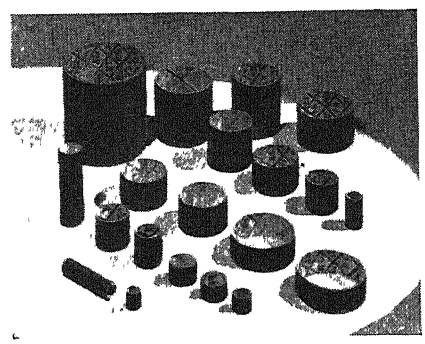
New Products

ABRASIVE BANDS

GRINDING and finishing of intricate pieces often causes delays and expenses far out of proportion to their size. This is no longer necessary if advantage is taken of the time- and money-saving grinding specialties developed and produced by the Minnesota Mining and Manufacturing Company, such as, for example, Three-M-ite Cloth Evenrun Bands. Reported to be fast cutting and long wearing, these handy abrasive bands turn out difficult jobs on what might be called a mass-production basis. Fitted over rubber mandrels of suitable size, Three-M-ite Cloth Evenrun Bands, with an electric drill, flexible shaft, or tool-room grinder to supply the power, make the individual finishing job a matter of seconds and are solving production problems in many plants.



Available in 33 sizes

Three-M-ite Cloth Evenrun Bands are available in 33 diameter sizes, ranging from 3/32 inch to eight inches, and with a face width of from ½ inch to three inches.

OSCILLOSCOPE

DEVELOPED and produced by the Reiner Electronics Company, a new five-inch cathode-ray oscilloscope of special design permits the study of complex wave forms such as square waves and pulses encountered in television work. Square wave signals from 40 cycles to 50 kilocycles can be accurately reproduced. The response up to one megacycle is great enough to make the unit useful at this frequency. This extended high frequency range makes this oscilloscope practical for the study and measurement of intermediate frequency phenomena.

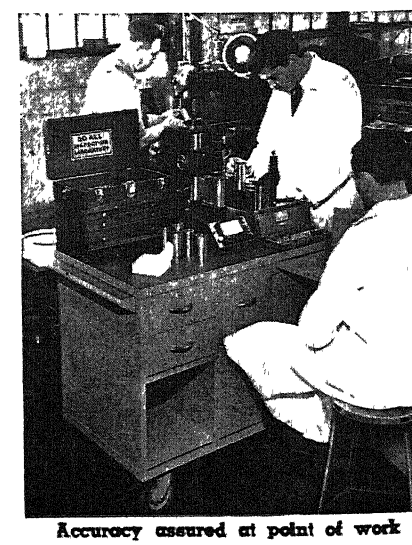
MOBILE INSPECTION UNIT

A COMPLETE inspection department that can be moved to any point of work is now possible through the use of the new DoAll Mobile Inspection Unit manufactured by Continental Machines, Inc. With this unit, all work-measuring instruments can be correctly set in tools and machines, a job that formerly required shut-downs and delays while the measuring instruments and parts were sent to the inspection department for checking. Now, however, the mobile inspection unit, occupying little more than an area 24 by 42 inches, and containing a complete precision inspection department, is wheeled right up to the point of work on any job.

The unit contains all the necessary instruments and gages ordinarily employed in an inspection department Monochromatic light waves, viewed through an optical flat, are used as the basic standard of measurement. A set of gage blocks, gaging instruments, and a comparator are provided to interpret this unwavering standard when checking dimensions of parts and tools The set of 83 precision gage blocks has an accuracy in height, flatness, and parallelism which is plus or minus .000004 inch. The set of 20 different precision measuring instruments includes calipers, trammel points, center points, scribers, base blocks, gage holders, vernier gage block, master square, sinebar, straightedges, master flat, and a precision surface plate. The comparator gage has four ranges of magnification, and an illuminated magnifying glass on a stand is also provided

The accuracy of these instruments which might be affected by wear, dirt, and rough handling, may in turn be quickly checked by using the optical flats and monochromatic light.

The mobile inspection unit is strongly built to safeguard the instruments and provide a smooth surface upon which to make inspection. It is of all steel construction which assures sturdiness and prevention of warp or twist. This forms a rigid foundation for the working surface which is covered with heavy-duty linoleum. This material provides a scratch-proof, smooth, shock-cushioning work surface that is easy on tools and gaging instruments.



Accuracy assured at point of work

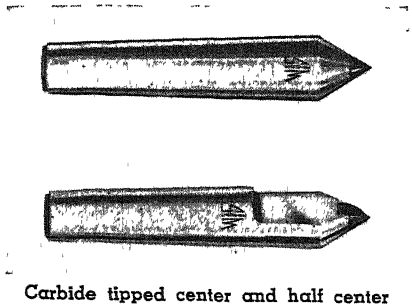
The unit is easily moved throughout the plant on four rubber tired, heavy duty caster wheels, which can be locked so that the unit becomes securely anchored when in use.

Every convenience is provided for the inspector so that he can quickly use his measuring instruments and record his findings and recommendations. A plug-in box is provided at the back of the unit to supply electricity for the monochromatic light, electric comparator, and magnifying glass. This box contains a 50-foot extension cord that is secured to an automatic take-up reel.

LATHE CENTERS

Longer service life for lathe centers and half centers is achieved by the extension of the carbide insert into the shank of the tool. This extension, as made by Wendt-Sonis, is approximately equal to the exposed portion of the tip, allowing extra regrinds before need of replacement, should the bearing surface of the tip become damaged.

Because of special precision manufacture, these lathe centers are guaranteed



Carbide tipped center and half center

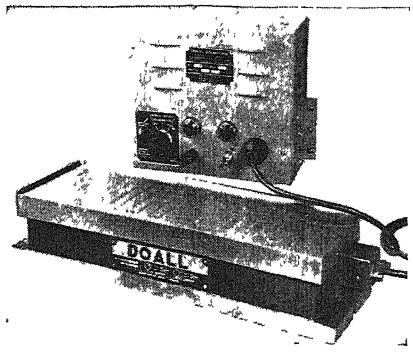
to a concentricity within 0 0002 inch or less, permitting finish grinding and turning to closer tolerances, and will hold this accuracy for a long time, due to the wear resistance of the carbide tip.

VERSATILE MAGNETIC CHUCK

Two new and related products—the DoAll electro-magnetic chuck and the DoAll Selectron, a revolutionary new current rectifying and demagnetizing unit—are made by Continental Machines, Inc. This combination, chuck and Selectron, improves and eases difficult grinding operations. Here for the first time the amount of magnetic pull of the chuck holding the work to be ground is under the control of the operator. The DoAll Selectron uses electronic power to control the flow of magnetic pull in the chuck and to demagnetize the chuck when the work is to be removed.

The DoAll chuck incorporates many features of construction which are unique in chucks of the electro-magnetic type. The entire unit is made of cast steel with high permeability to provide the maximum of work-holding power with the minimum of current consumption. All parts are precision ground before assembling for positive contact between the parts of the magnetic circuit, thereby eliminating power-wasting air gaps.

The working surface of the chucks



Magnetic chuck and control

are ground to mirror finish with the sides and ends square and parallel so that they form a base to aline the work piece when using the adjustable stop plates on the end and side of the chuck.

The Selectron is an electronic device utilizing tubes for full-wave rectification of alternating current in supplying direct current to the chuck When demagnetizing, the current is alternately reversed and reduced by the Selectron to withdraw all residual magnetism from the chuck.

This entire process of demagnetizing requires but a few seconds, after which the work is easily removed from the chuck without pulling it against residual magnetism. This saves considerable time in locating the work on the chuck preparatory to grinding as well as in the removal of the work after being ground In addition, all sides of a job can be ground to high finish without danger of scratching when removed from the chuck.

BRUSH CLEANER

High-pressure research seeking relief from the scarcity of essential products has achieved signal success in the case of the humble paint brush, especially the rock-hard, ready-for-discard kind of brush The relief agent is a new and different sort of cleaner known as Prestorer. Acting on a different principle from established solutions, Prestorer is reported to be potent, easy to use, economical, and non-hazardous.

Unlike tires, paint brushes cannot be recapped, but by the simple use of Prestorer they can be reclaimed, their lives prolonged, and their mileage records tremendously increased. The use of this cleaner is simplicity itself. All one has to do is to immerse the bristles in the solution. Recently used brushes become clean in a few hours; "hard as rock" old timers cleanse themselves in from 12 to 96 hours. The oldest and toughest of brushes obtain a new lease on life, while frequently used brushes are kept young and free from the slow death that comes from allowing paint to harden in the base.

According to the manufacturers, Technical Development Laboratories, Prestorer will not injure the hands for it contains no high-powered caustic alkalies; it is never a fire hazard since it is non-inflammable. It may be used safely in poorly ventilated rooms, for it gives off no poisonous fumes.

The action by which Prestorer does its work so efficiently is interesting. It

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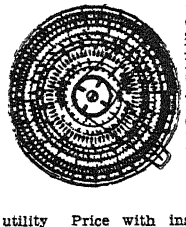

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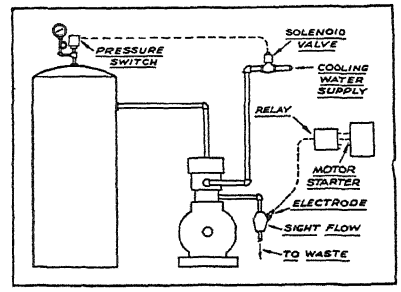
lies in the absorption of part of the solution by the bristles. The bristles swell, causing the hard paint pigment to crack off. After drying, the swelling disappears and the bristle returns to normal size without injury. Since the pigment is not dissolved the solution may be strained through cheese cloth every once in a while and thus is kept clean for reuse

RUBBER BELT SPLICING

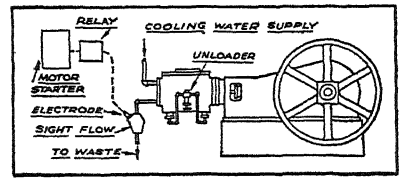
BELTING made with the new synthetic rubber from government plants, known as GR-S, can be joined to natural rubber belting with a vulcanized splice This makes it possible to use sections of the new GR-S synthetic belting to repair existing belting when needed Standard splicing and repair materials can be used with the synthetic belting

COMPRESSOR CONTROL

TO PROTECT water-cooled compressors against damaging overheating that results if they are operated without cooling water, and at the same time to



Automatic control on compressor (above) and on unloading compressor (below) prevent operation unless cooling water is actually flowing



prevent unnecessary and costly waste of water, the Johnson Corporation has developed a new automatic compressor control. By permitting the compressor to operate only when water is actually flowing through it, this control guards against failure of water supply from any cause whatsoever, and consequently permits the safe use of automatic water cut-off valves.

The new control consists of a sight-flow fitting, mounted in the water discharge pipe of the compressor, which serves as a holder for a metal electrode. When pressure in the receiver falls below the pre-determined level, the pressure switch on the receiver opens a solenoid-controlled valve to admit cooling water to compressor. Compressor is not started until water flows through it and into the sight-flow, completing circuit with the electrode. If for any reason the water supply fails, compressor will not be started or, if operating, will be stopped immediately.

This arrangement of the control is designated as Type M. By supplying cooling water only while compressor is actually operating, it will prevent costly waste of water in those many installations where cooling water is left running all the time, even though compressor operates only intermittently. The new control is also available as Type U, for use on unloading compressors. It insures that cooling water is flowing before compressor starts, and stops compressor or sounds warning alarm if water supply fails.

ELECTRIC TRUCK CONTROLLER

IMPROVED economy in current consumption is claimed through the use of a new four-speed reversing controller for electric and gas-electric trucks. Experience with this device, manufactured by The Elwell-Parker Electric Company, has shown that when motor current is restricted by introducing resistance on first, second, and third speeds, a wasteful amount of current can be consumed by running the truck for protracted periods on any of these three speeds. The major portion of this possible waste of current is prevented by the new controller, which uses resistance on the first speed only. An additional power saving is attributed to the manipulation of the motor fields, connecting them in series on first and second speeds, which produces greater torque with less current consumption.

INSULATED GENERATOR DRIVE

INDICATIVE of the trend in design of both war and post-war products to save space, to make fewer parts do more work, and to increase general efficiency, is a new splined shaft coupling designed and now being produced for a manufacturer of electric power generators by Bushings, Inc. The coupling is designed to stop the transmission of noise, absorb any shock and impact, and to compensate for misalinement between drive and driven shafting on a 75-horsepower engine-driven generator.

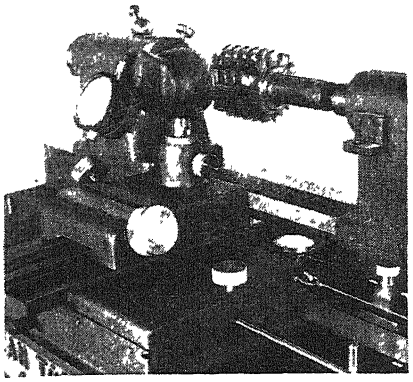
Using synthetic Neoprene as the insulating medium, to permit operation in the presence of lubricant, the new coupling consists of only a splined inner sleeve, a flange, and the separating bushing of synthetic. The new design eliminates a separate flexible coupling and reduces the space that would be required for such a coupling.

The same general design, with either keyway or splines, is capable of handling virtually any load merely by use of the proper hardness and thickness of the rubber or synthetic

CUTTER CHECKER

A SINGLE machine, designed to check the correct resharpening of hobs or milling cutters, has been added to its "Sine-Line" gear and gear cutting tool checking equipment by Michigan Tool Company.

To simplify setting of indicators for checking rake angle, parallelism, and so on, a ground surface angle block, the top edge of which is in the same horizontal plane as the headstock and tail-



Checking a hob after sharpening

stock centers, and the projecting ledge in a parallel plane, is mounted on the tail-stock and used for initial indicator settings. The projecting ledge is used with "Jo" blocks to set indicator for checking hooked or raked hobs The indicator base is ball bearing mounted for freedom of movement, and in a plane parallel to the horizontal plane of the centers Initial settings are accomplished by rolling the indicator opposite the ground surface block, and adjusting the vertical setting of the indicator "Jo" blocks may be placed on the projecting ledge so that any desired setting may be obtained, on, above, or below center

After the initial indicator setting, the indicator base is returned opposite the tool for checking sharpening inaccuracies A small weight, suspended over a pulley, propels the sliding indicator base, when checking parallelism, or lead in the axial plane A knurled locking screw will hold the base in any desired position.

MARKING WITH DRAW DIES

AN IMPROVED method for marking part numbers onto deep-drawn steel and other parts at no additional cost makes use of precision engraved knockout pads, produced by New Method Steel Stamps, Inc.

The necessary figures and numbers are engraved on the upper surface of the pad itself, making the one piece a combination of knockout pad and marking die When in use, the knockout pad is backed by springs It numbers the bottom portion of the stamping during the actual drawing process, and then lifts the finished piece out of the die after the male half of forming die has been withdrawn. The incorporation of a stamping device with a knockout pad in this manner makes possible automatic marking at no extra cost.

TOUGH NUTS TAMED

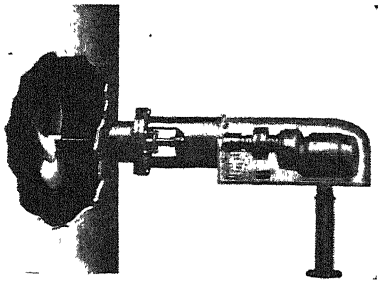
CREEPING into infinitesimal openings, a new chemical combination has already saved time in many war-busy plants and kept hard-to-replace parts from falling under the chisel and hammer. In one case a frozen shaft threatened to tie up production for half a day or more. An application of Kano Kroil resulted in production being resumed in 15 minutes. A bridge had been exposed to the elements for twenty years when the engineer found it necessary to remove some bolts After applying Kano Kroil the bolts were removed quickly and successfully Laboratory tests are reported to show that the chemical creeps into spaces as small as a millionth of an inch; actual working tests prove that it saves time, temper, and materials by loosening frozen metal parts quickly and effectively without harm to metal.

LACQUER WAX

SALT SPRAY resistance and moisture proofness of lacquers and varnishes can be greatly increased by the addition of small percentages of Acrawax C, powdered, a synthetic wax produced by the Glyco Products Company, Inc Unlike natural waxes, Acrawax C does not retard the drying properties of the lacquer or varnish The Acrawax C, powdered, should be treated as a pigment and ground into the resin. The clarity of the varnish is unaffected

NEW TANK AGITATOR

OUTSIDE repacking without draining the tank and without loss of liquid, is one feature of a new side-entering agitator introduced by H K. Porter Company, Inc The outside repacking



Agitator with outside packing

can be done in five minutes, saving many man hours as well as the expense of draining the tank, airblowing it in cases where toxic fumes make this necesary to permit a workman to enter, and then pumping back the fluid after the packing has been replaced. This is accomplished by using an external packing gland and a seal attached to the shaft inside the tank which is drawn into a seat, hermetically sealing off the tank's contents.

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FREEDOM from vibration in a telescope is usually secured—or partly secured, since this is a relative term—at the expense of added weight and loss of portability Lyle T Johnson had built his first telescope when in high school and found it vibrated badly in the slightest breeze Later, when an undergraduate at the University of Wisconsin and majoring in physics, he resolved to beat the vibration devil but at the same time found that he required a portable telescope Often these two aims tend to conflict. Figures 1 to 4 show how he worked out this practical problem on an 8" reflector.

He lived in a university dormitory with a flat deck roof and could store his telescope in the attic. To use it he had each time to carry it in five knocked-down parts up a ladder, through a small trap door in the roof, and assemble it on the roof, reversing the same patient processes after observation He built the telescope mainly of wood, and its knock-down was made possible by removing five wing nuts and loosening some others

The pier is made of two-by-fours and opens up like a jaw when the wing nuts that attach the diagonals (Figures 1, 2) are removed. Polar axis drops out.

The polar axis is a composite of steel and wood. Apparent in the photographs is its box truss made of one two-by-ten, two two-by-sixes, and a two-by-four, the first three of these being neatly tapered. Within this box truss is a 1¼" steel shaft with a two-roll ball bearing at either end Later, when a clock drive is added, it will drive the shaft continuously but the wooden truss will be movable on it to permit pointing the telescope at different objects.

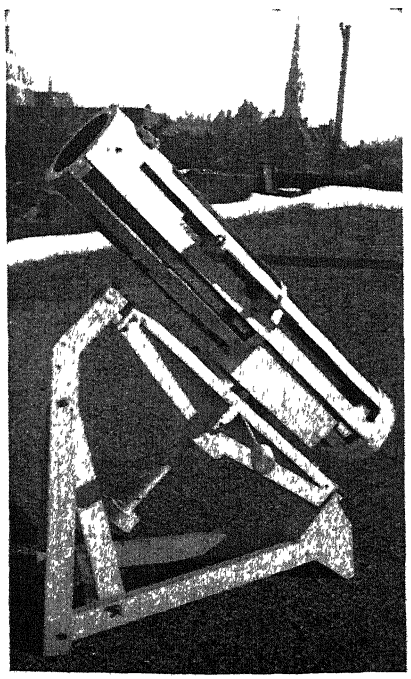

Figure 1: Johnson's reflector

The declination axis is 25" of 1¼" shafting with a narrow 9" pulley on the tubeward end, to which the tube cradle (Figure 3) is attached. This pulley rolls on three ball-bearing rollers (Figure 4) mounted on the wooden truss of the polar axis and there is a second bearing on the opposite side of the truss The end thrust is taken by brass plates on the truss and there is a simple wooden declination clamp

Because two things cannot occupy the same space at the same time, the 1¼" declination axis had to be offset 1¼" from the 1¼" polar axis shaft This necessitated the addition of a small auxiliary counterweight and this, Johnson states, was found to vibrate when touched—a pointer for others.

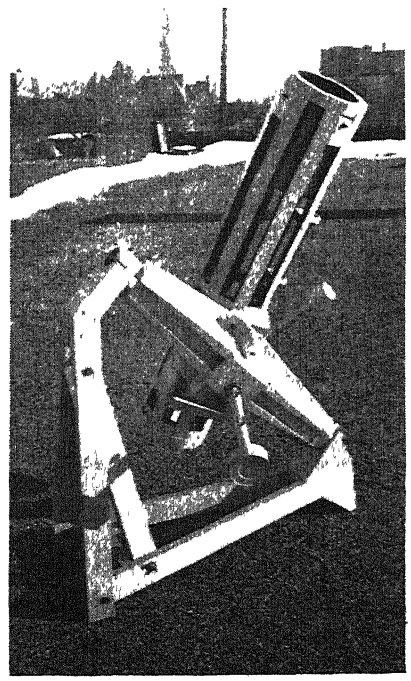

Figure 2: Note polar axis

The tube is all wood, made of eight pieces each ¾" by 2¼", attached to three doubled, grain-crossed, and glued wooden rings. The cell is also of wood. The tube is attached to its cradle by means of four wooden turn-buttons with wing nuts to snug them up. If, during observation, the eyepiece position becomes awkward, it is but a moment's work to remove the tube, rotate it in the hands and re-attach it in a new position—a fairly good and simple substitution for a turning ring

The mirror will pass the diffraction test, Johnson says, and when analyzed by the Wright method ("A T M", p 257) the maximum departure is less than half a millionth inch It is mounted on a three-point support

The telescope is now at the Washburn Observatory, University of Wisconsin, Madison, Wisconsin, where it is used by members of the Madison Astronomical Society. Johnson (Box 236, La Plata, Md.) is now a Junior Physicist at the National Bureau of Standards

The impression created by close examination of the original photographs under a glass is that all details of this telescope are neat and shapely—there

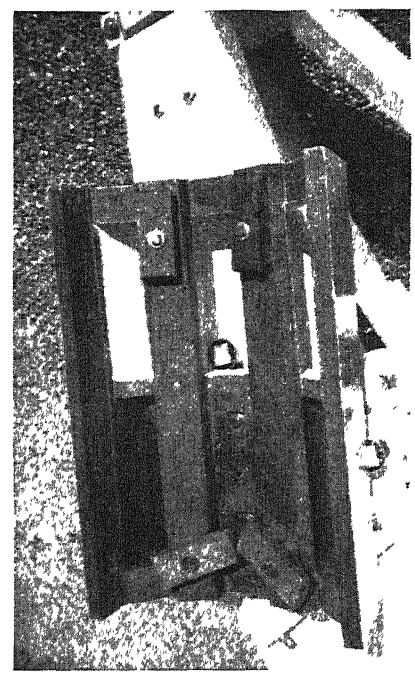

Figure 3: Cradle and buttons

are no cobbled-up messes—yet the cost of such a mounting should be low. This telescope is not presented as spectacular or remarkable but rather as one good, inexpensive model for a solid telescope of modest size that is within the range of the average beginner or near beginner—near beginner because it perhaps is best, all things considered, deliberately to cobble-up the first telescope and use it for a time in order to let certain practical facts sink in As Johnson says, "This 8" telescope is superior in every way to my old 6", due to the application of experience gained in the construction and use of the first one"

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First attempts at such a lap probably wouldn't look exactly artistic but practice teaches much. For a regular polishing lap West extends a number of parallel wavy lines continuously across the lap and finds it produces a smooth mirror surface free from zones. For mirror defects he pours special laps having whatever outline he wishes. It's all quick and simple

In the kitchen the ladies add frills to cake frostings with a kind of squirt-gun loaded with sugary goo, and something of this kind might be used for

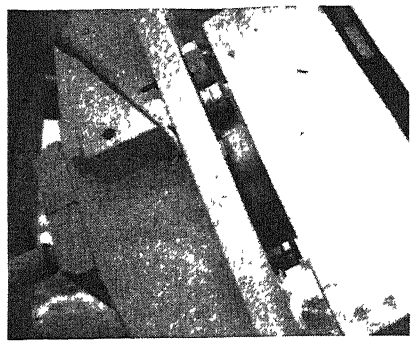

Figure 4: Pulley and rollers

making laps similar to those of West; or this may be only a half-baked idea of your scribe's. It hasn't been tried out A danger would be from explosion if a load of chilled pitch in it were remelted incautiously. One amateur spent several helpless weeks with his hands in big bandages as a result of applying heat to the bottom of a can of pitch As the bottom layer melted and expanded, the pitch had no place to go and the can blew up in his face He was really pretty seriously injured Thereafter, when re-melting pitch in a container, he started by melting an escape channel from the top down, at one side Worth remembering, he thinks.

THIS MONTH we have a new addition to the turret telescope family, a simple refractor (Figure 5) with an auxiliary optical flat, designed by Winston C Juengst, New York, N. Y

As in all turret telescope designs, Juengst's idea aims at comfort and ease of observation, as a turret is sealed equally to winter's cold and summer's 'skeeters A simpler and neater design, from both optical and mechanical standpoints, is the chief contribution

In Juengst's design only one extra optic, in addition to the usual refractor, would be required. This is an aluminized optical flat about 1.5 times as large as the O.G. diameter As Porter well emphasizes, such a flat would have to be a good one, say to a tenth wave or better. However, a good reflecting telescope should be made to one eighth wave to give maximum performance, so this should not stump anyone who can make a first class reflector. Furthermore, the flat will be a valuable aid in constructing the O.G, so the same effort will serve two purposes.

Other advantages to the design are fairly obvious. All parts of the heavens and horizons can be reached with ease, and with the eyepiece always in a comfortable position below the horizontal. A large part of the telescope is within the turret, rotating upon its own axis for the declination setting, hence awkward projecting parts and weights are avoided Both axes are as stable as could be desired, hence both ease of operation and steadiness are assured, if the construction details are well attended to The instrument is made ready for instant use merely by removing the cap from the flat housing Auxiliary instruments, such as a camera or spectographic equipment, may easily be supported by the turret at the focus.

Two amateurs to whom the above description was shown, previous to publication, debated about it thus

Nip: "This turret reflector of Juengst's is really a modified Hartness telescope in principle; see 'A T.M.', page 50 What Juengst really does is to push Hartness' diagonal out to and beyond the objective The telescope would be simpler to make than the Hartness type, but is not so stable; also, errors in the small flat would be magnified more than in the Hartness type with diagonal close to the focus."

Tuck "Nip is partly right. However, most of the turret and related systems in 'A T.M.' page 50 do just this The Gerrish telescope at Harvard is identical optically to Juengst's. It is an old-timer, and appears to have been a success. The use of a flat outside the objective is old stuff, not a radical new idea"

The Nip-and-Tuck debate was then referred to Juengst who commented "The only reasons I submitted this idea were to provide a more elegant design mechanically, free from overhanging tubes, big counterweights, and so on, also to stimulate post-war trends toward turret telescopes, especially refracting types. Too many good observing nights are lost because one's courage is not equal to the weather. The standard tolerance for a plane outside the O.G. is 0.1 wave. Anyone competent to do a good job on the rest of the telescope should be able to make a flat of that quality But I can't see how this design resembles the Hartness turret"

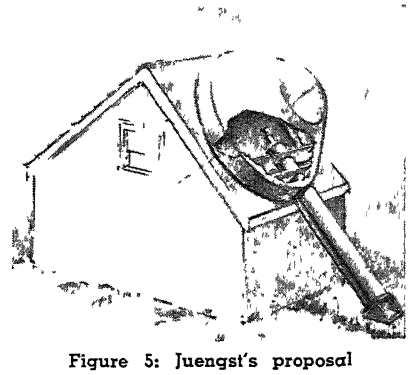

Figure 5: Juengst's proposal

Unfortunately, on March 25, after the above item was prepared, Juengst died He had turned professional, and was doing optical ordnance work for the Navy. He was one of our earliest amateur telescope makers and came annually to the Stellafane conventions from the time he was a boy, 15 years ago. He was a graduate optometrist, University of Rochester.

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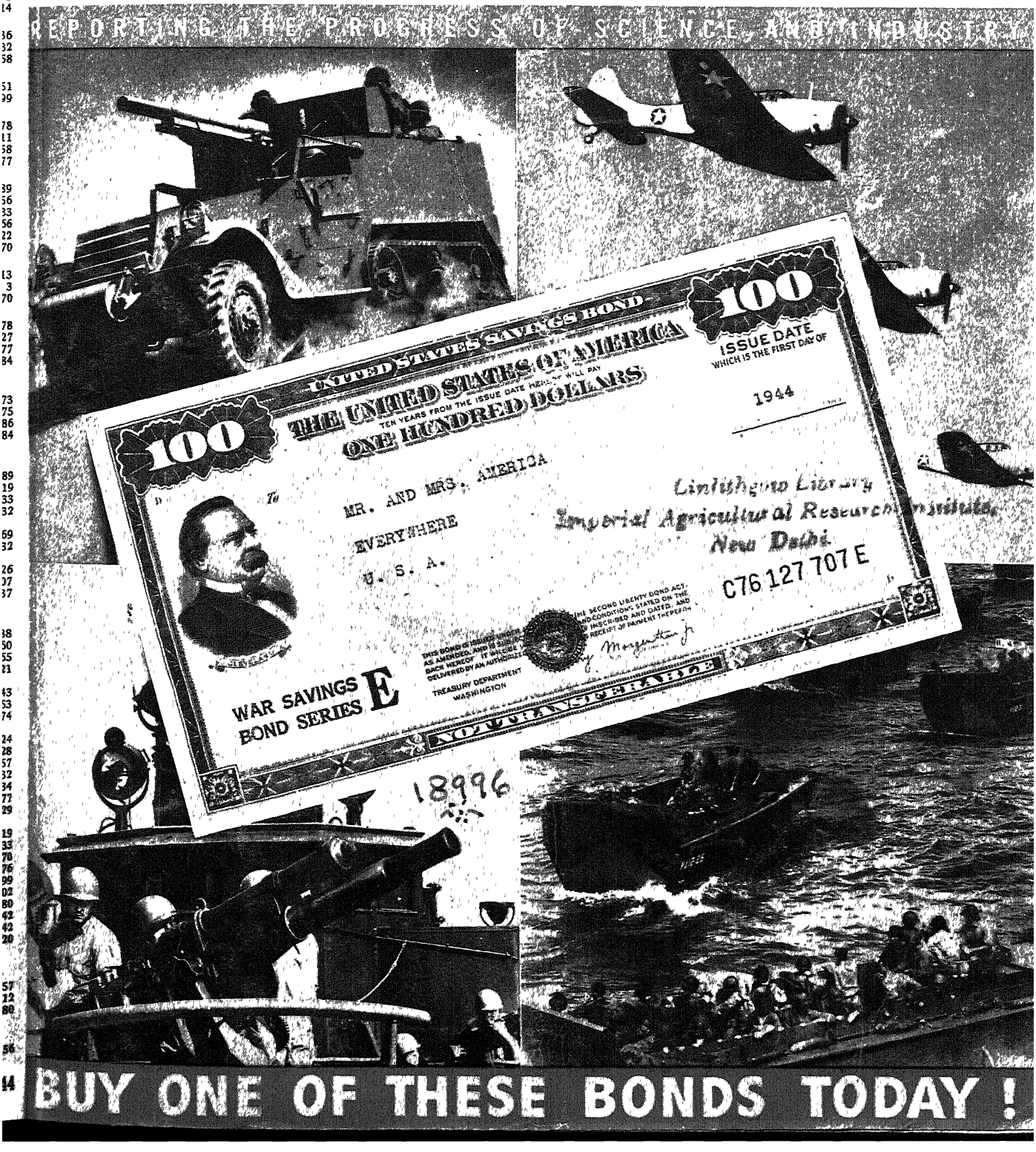

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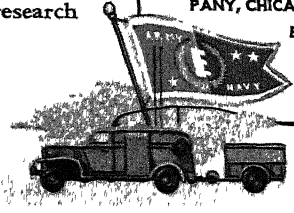

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Previews of the Industrial Horizon

By A. P. Peck

STANDARDS FOR TELEVISION

PROBLEM-CHILD of the radio industry, television has been kicked around by the industry and the press alike for many years. Came the war, and the meager knowledge of television technology, painstakingly acquired during those years, blossomed mightily behind the closed doors of government-controlled laboratories There the problem-child has given birth to a number of developments which so far can only be mentioned in generalities. But even with war-necessitated research being directed toward military problems, television itself has benefitted. Benefitted, indeed, to a degree where television is now ready for at least a minor boom as soon as the light turns green

Now, however, come further complications Television has always been plagued with the necessity for standards that will permit a receiving unit to pick up the vision-broadcasts Transmitters and receivers must both be designed for these standards and any deviation from them, at either end, makes operation impossible.

Before the war, television was struggling along and had reached the point where standards were set—set in the light of then-available knowledge. Since that time progress has shown that pre-war standards are not good enough for the type of television that can now be offered to the public. What to do? Maintain two standards and sell two types of receivers? Or junk the pre-war standards and set new ones based on advanced knowledge? Here is a problem that has the radio industry up in arms.

If two standards are maintained side by side, everyone will suffer—public and industry alike If the pre-war standards are kept, in favor of better standards, then the public will have available only an inferior type of television—not the best that can be provided. If revised post-war standards are adopted, it may take a while longer to get television to the public but when they do get it, it will be as high in quality as can be furnished.

No one is going to suffer much if we have to wait a bit longer for television. It has been promised so often that a few post-war months more will make little difference. When television at last becomes "big business"—and it certainly will become just that—it should not be handicapped by antiquated ideas and standards.

More comment on this subject, straight from the radio industry, on page 27.

TRANSPARENT MODELS

NECESSITY for quickly training production employees in war work has given rise to many instruction tricks. Latest of these involves the use of full-sized models of valves, pumps, and the like, fashioned of crystal-clear plastics. Available plastics can be machined to size and shape accurately. Then, when assembled with interior parts made of opaque materials, the plastic exterior enables the student to see just what goes on inside. With such visual knowledge, he is better equipped to do any job connected with the assembly which he has studied in plastic form. That such models are far better than the more conventional cut-aways goes without saying, since the interior parts can be seen from any angle and in true perspective.

ADHESIVES

SPRINKLED through the news of technology for the past few years have been mentions of various advances in the science of adhesives. Edge-glued lumber, better plywoods, metal-to-metal bonds, are only a few of the developments made possible by this progress.

Now comes news of a rubber-like adhesive which is particularly adaptable to use in many branches of construction. By means of this new adhesive it is possible to bond a very thin layer of wood veneer directly to a metal surface and to accomplish this result quickly and with the use of only moderate heat and pressure. The end result is not a new one, since wood-faced metal sheets have been fabricated in the past. But, by the new method, costs and the time factor are radically reduced. Further, the new bonded materials can be stamped, cut with shears, and bent into almost any shape without disturbing the bond or cracking the wood.

The practical and decorative effects of this new wood-metal combination can go far. Home interiors and furniture, airplanes, trains, ships, and so on, are likely places for use of this type of paneling in which strength and weight factors of metals can be combined with the warmth and beauty of wood.

CORROSION CONTROL

DESPITE the fact that corrosion has annually taken its toll of millions in dollar-value, it seems that only desultory attempts were made to control this waste until the fortunes of war were seen, in some theaters, to turn on a film of rust. Vital supplies, piled on some beach in the South Pacific, rusted rapidly, became worthless Parts of the story of what has been done to combat this waste is told in the article on page 22, where petroleum derivatives are described in their protective role. On other fronts the fight has also been waged. The paint industry has become more alive than ever to the possibilities of paint as a protective medium Better metal coatings have been devised to keep rust to a minimum. Plastic sheaths, that are removed before an article is placed in service, have been developed to protect highly polished surfaces from corrosion between the final finishing operation and actual use.

All-in-all, industry can see on the peace-time horizon at least partial freedom from the inroads which corrosion has made in the past.

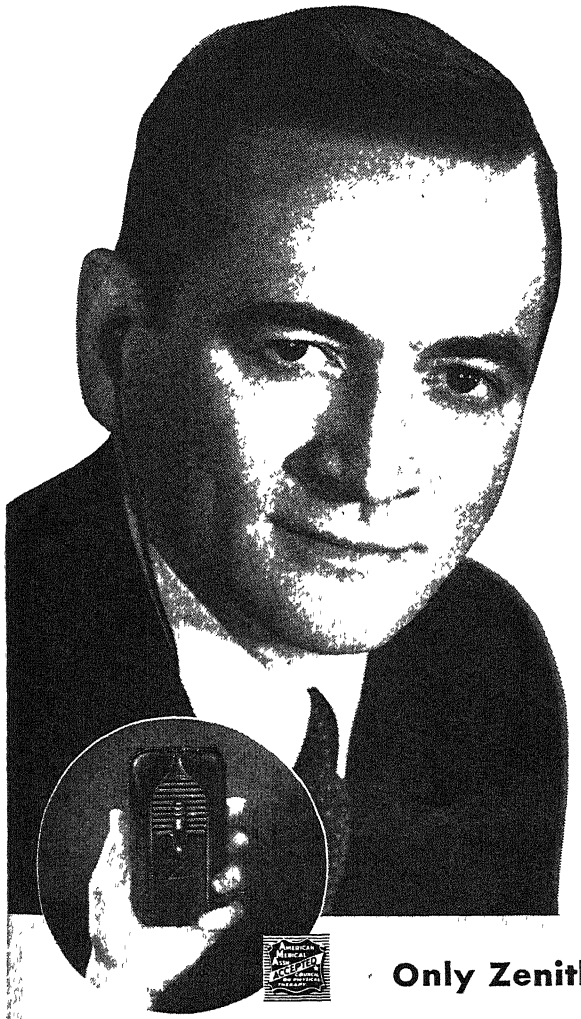
SYNTHETIC RUBBER RECLAIMED

WHEN synthetic rubber first entered the over-all picture of our national economy in a big way, it was considered to be a completely expendable product. None of the formulas applicable to reclamation of natural rubber would work with synthetic. Now, however, formulas and processes have been developed by means of which scrap synthetic can be reclaimed—using the same machinery used for reclaiming natural rubber—and turned back to the manufacture of the identical items for which it was previously used. Already more than a million pounds of synthetic have been reclaimed.

FOR FUTURE REFERENCE

PROBABLY the first commercial post-war use for gas turbines will be as power units for railroads, with airplane drives, ocean ship drives, industrial power, and electric power generation following in that order. . . Chlorine dioxide, valuable as an industrial bleaching agent, can now be made on the premises by a newly developed generator. . . Jets of oil, impinging on the under side of Diesel pistons, hold promise of keeping down excessive combustion-chamber temperatures. . . Chemical engineering is making possible extensive reductions in the cost to the consumer of synthetic vitamins. . . Fire-fighting methods, intensively developed for military purposes, will reduce post-war fire tolls.

No One Need Pay More than $40 for a Quality Hearing Aid!



America's Overwhelming Swing to the New Zenith Radionic Hearing Aid Proves It!

SUCCESS speaks for itself! America's hard of hearing—eager to enjoy a fuller life, to take a more active part in working for Victory—are buying the Zenith at a rate undreamed of before in the hearing aid industry! Here, indeed, is conclusive evidence that no one need pay more than $40 for a quality hearing aid!

How can Zenith bring its finest quality thus within reach of all? One reason, of course, is Zenith world leadership in the exclusive manufacture of radionic products Another is this: The Zenith is built not to a price, but to an improved, modern *principle* of hearing aid design· INSTANT PERSONAL ADJUSTMENT. You, yourself, "focus" this instrument for your particular hearing needs—for different voices and surroundings—as conveniently as you focus a pair of binoculars!

That's why the Zenith requires no elaborate testing and frequent adjustments by high-paid, high-pressure salesmen...no special offices, home calls or other expensive "trimmings." *Zenith Quality Is in the Instrument Itself!*

No longer is there any reason to delay hearing a demonstration. You owe it to yourself—to your country—to all who have your interest at heart. Your local Zenith-franchised optical establishment invites you. No one will urge you to buy, or call at your home. For free descriptive booklet, sent in plain envelope, mail the convenient coupon below—today

$40 COMPLETE, READY TO WEAR
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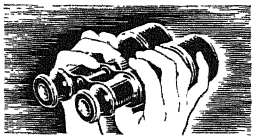
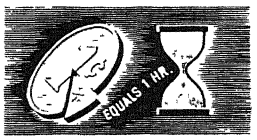
Only Zenith Gives You These Great Advantages



1 New "Self-Focus" Hearing Control

The flick of your finger brings hearing into range for your particular needs—for different voices and surroundings—as conveniently as you focus a pair of binoculars. Outmodes the old-way "fixed-adjustment" principle.



2 New Low-Operating-Cost Battery Circuit

An exclusive circuit—especially developed by Zenith engineers to insure outstanding performance throughout the life of the batteries Brings average operating cost to only 3/10 of one cent per hour.

3 Zenith's Finest Quality —About ¼ the Price

You get the fine precision that modern knowledge and engineering made possible, at about ¼ the price of other quality vacuum tube instruments! One model—no "decoys" One quality—Zenith's finest One price—$40.

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Guaranteed by Zenith, world's leading manufacturer of radionic products exclusively, for a full year You also get unique Zenith 5-year Service Policy with coverage enjoyed *exclusively* by Zenith wearers.

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Accepted by American Medical Association Council on Physical Therapy

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Good news for our Canadian friends. The new Zenith Radionic Hearing Aid is now available in Canada—Direct by mail only—at $40 complete (Canadian Currency) with no additional charge for transportation, duties or taxes: For particulars write our Canadian distributor, Zenith Radio Coporation of Canada, Ltd., Guaranty Trust Bldg., Windsor, Ont.

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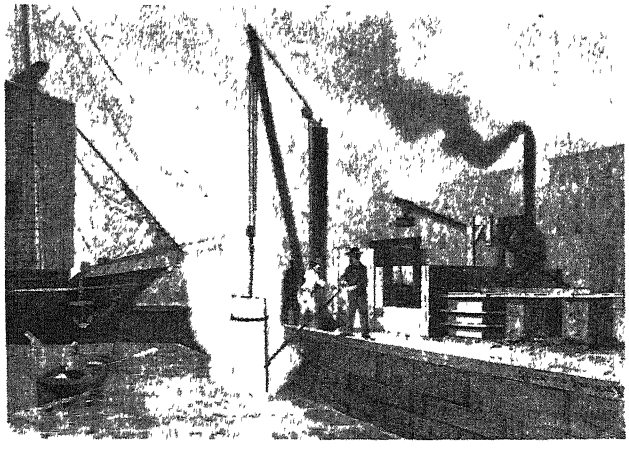
50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of July, 1894)

ATLANTIC CABLE — "On the 2d of July the Faraday completed the laying of a new Atlantic cable, the actual time occupied in the work of laying the deep sea portion being but twelve days. When the Great Eastern, in 1866, completed the laying of the first successful Atlantic cable, the entire world joined in congratulations. The event was justly looked upon as marking an era in the progress of the world Since that time, however, the making and laying of ocean cables has become a practical, everyday business, and the new cable was not only laid in the shortest time, but is a much better cable than any of its predecessors, having the largest copper conductor and being the speediest ever laid for its length."

HARDENING STEEL — "The manufacture of iron and steel burglar-proof vaults for insurance companies, trust companies and similar institutions is one of increasing importance As the safe maker advances in his processes, and while he is improving the burglar-proof quality of his safes, so fast does



the burglar improve in his method of attack, so that it is often the burglar himself who is in advance of the safe builder. The illustration . . . shows a somewhat curious operation incidental to the manufacture of steel and iron vaults, the hardening of the plates. The process is the one employed at the works of J. B. & J. M. Cornell, in this city, and consists in dipping the hot plates into salt water. Advantage is taken of the water front held by the firm in utilizing *in situ* the salt water of the Hudson River for the purpose, a brine dip being considered superior to one of fresh water. . .Special heating furnaces are built in the open air upon the margin of the river, and plates of steel heated in them are dipped into the river to harden."

GARBAGE UTILIZATION—"The process of garbage disposal is . . . probably carried on now with greater perfection in St. Louis than anywhere else in the world. . . Carts bringing the material . . . discharge into enormous vertical cylinders, which are surrounded by steam jackets. Superheated steam is forced into the jackets, and the water, which constitutes from 75 to 80 percent of the garbage, is thus evaporated. . . After extracting the grease, the residuum in the cylinders is dried a little more . . It is now a brown mass, free from all unpleasant odor, and apparently dry, although it still contains 5 or 6 percent of water. As it has not been heated sufficiently to cause destructive distillation of the solid portions, it contains practically all the nitrogen of the fresh garbage, with, of course, all the alkalies and phosphates, and, after grinding coarsely and packing in barrels or bags, it commands a ready sale all over the United States'

GAS-ICE — "An Indianapolis firm has constructed a refrigerator for making ice by means of the cold produced by the expansion of natural gas to atmospheric pressure This is the principle of all artificial ice machines; yet it seems to have only just occurred to some American engineers that natural gas as it issues from the wells at pressures amounting in some instances to 20 atmospheres, and at a temperature of 42° Fah., presents the sole physical condition necessary for the production of cold by gaseous expansion"

ELECTRIC BOATS — "Of the five or six hundred electric roads in this country a large proportion reach natural or artificial waters, such as lakes or rivers, and in all parts of the country a large amount of work is now being done in the utilization of the current from the trolley wires for charging storage battery boats to ply on these waters"

RAILROADS — "The total mileage of railways in the United States on June 30, 1893, was 176,461 07, being an increase during the year of 4,897 55 miles. The corresponding increase during the previous year was 3,160 78, from which it appears that there was some revival in railway construction during the year covered by the report"

PULP PIPES — "Wood pulp is agitated with water and rolled on a tube. After the . extra amount of water drains away, it is placed on end and the interior mould is withdrawn, leaving the wood pulp tube . The further process consists of dipping it into a very hot solution of asphaltum and other materials, which penetrate the whole substance The ends are then squared up, and the threads cut, or taper finish is made in the usual manner of wrought iron pipe. This material, when finished, possesses high electrical resistance, rendering it suitable for underground conduits for electric wires."

AUSTRALIAN GOLD—"Some big stories are current of the Coolgardie gold fields in Western Australia, and particularly of one mine in the district discovered by two young adventurers named Bailey and Ford . The monthly output from the mine now amounts to 2,000 ounces From 30 tons of ore picked from a bulk of 1,400 tons, 18,000 ounces of gold was obtained, and the remainder of the stone is expected to yield from five to six ounces to the ton"

STRIKES—"It is to be regretted that the people of the United States should have to recover the use of their ordinary highways at the point of the bayonet, but it is is better to recover and hold them in that way than to give up the control of them, even for a moment, to people so reckless and malicious, or so unutterably base, as those who have managed the great railroad strikes for the past ten years."

TURBINES—"In a paper on the Laval steam turbine, read before the French Society for the Encouragement of National Industries, it was stated that, though invented only in 1891, some 200 of the motors are now at work, ranging in size from 5 to 100 horse power The speed of rotation ranges from 15,000 to 30,000 per minute, the steam issuing from the guides at the full speed due to its pressure. Owing to this it is not necessary that the wheel should fit closely into the guide chamber, as there is no tendency to leakage."

GLASS BRICKS—"Glass building bricks . . are hollow, being blown like bottles, and are given forms—such as cubes, hexagons, etc.—that permit of ready laying. A bituminous cement, with a base of asphalt, is used with them The bricks serve as double windows, giving protection against both cold and heat; they are good insulators of humidity and noise, and they lend themselves readily to the decoration of buildings, either by their form or color."

ARC LIGHT—"The light of the carbon arc is not, and can never be, white, as it is sometimes described as being, but must always be tinted violet by the carbon vapor normally present between the rods."

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These are traditions of the telephone business.

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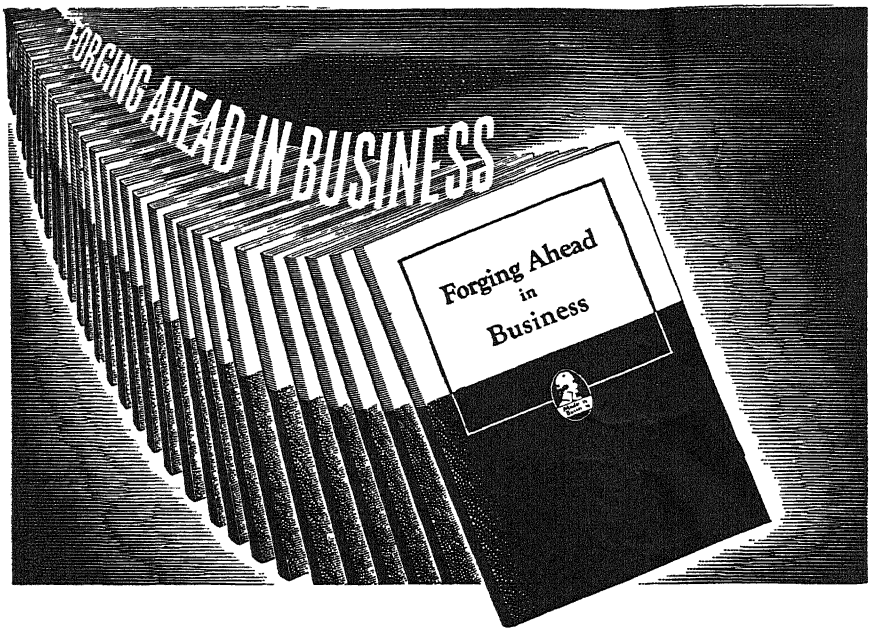
Even in today's rush and hurry, "The Voice With a Smile" keeps right on being a part of telephone service.

BELL TELEPHONE SYSTEM

When you're calling over war-busy lines, the Long Distance operator may ask you to "please limit your call to 5 minutes." That's to help more calls get through during rush periods.



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FORGING AHEAD IN BUSINESS contains a message of particular importance to production men. This is your opportunity to obtain a copy of this famous book, which has been described as a "turning point in the lives of literally thousands of men"!

Although "Forging Ahead in Business" has been distributed to more than 3,000,000 men, today's timely edition was written in the light of recent world-wide developments. Its 64 pages represent more than three decades of successful experience in training men for leadership in business and industry.

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Send for "FORGING AHEAD IN BUSINESS" TODAY!

Frankly, this booklet has no appeal for the immature mind. It does not interest the man who, for one reason or another, is wholly satisfied to plug along in a mediocre job. But, for the alert, future-minded individual—the man with ambition and "drive"—"Forging Ahead in Business" has a message of distinct importance. If you feel that it is intended for you, don't hesitate to send for a copy today. Simply fill in and mail the coupon below.

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"Quotes . . ."

"UNFORTUNATELY, theorists in government feel that they know just how to run industry so as to produce Utopia. But the operation of an industry, as the industrialist knows, is one of the most intricate problems that man handles It is obviously impossible to operate industry by rule. The only way, however, that government can run any activity is by dogmatic direction. That must fail in industry as we so clearly see now" James F Lincoln, President, The Lincoln Electric Company.

" " "

"THE BEST that can be hoped for in a college training is to make the student cognizant of what education means, and to guide him so that he may have the urge through study and reading to become educated." *Dr. Roger Adams, University of Illinois.*

" " "

"THE [POST-WAR] COMPETITION between research departments will be just as keen as that between sales departments. The manufacturer of a finished product will have to pay more attention to and spend more money for research His organization will not only have to keep currently informed about his own final products, but also will have to keep up with the procession in new knowledge of raw materials and processes." Clyde E Williams, Director, Battelle Memorial Institute.

" " "

"IT SEEMS PROBABLE that business . . . will not be able without additional financing to produce and distribute the volume of goods and services necessary to provide full employment." *Professor Charles C. Abbott, Harvard Business School.*

" " "

"WE SHALL have been criminally negligent if during these times we fail to plan for the job beyond. In my opinion any assumption is unsafe and dangerous, that we will just automatically have full employment because of the combination of scarcity of goods and high purchasing power." Howard E. Blood, President, Norge Division, Borg-Warner Corporation.

" " "

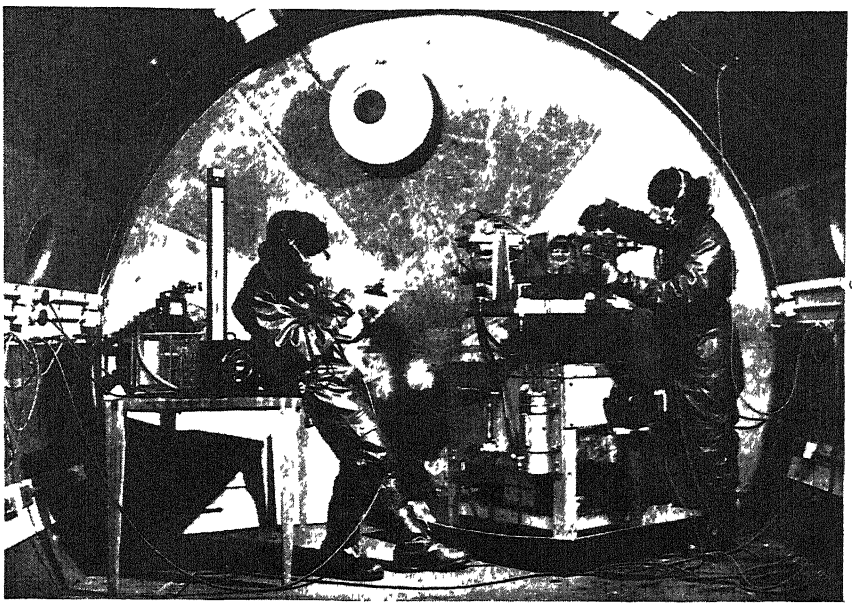
"PASSENGER SERVICE to cities now denied the advantages of direct air travel will be an important factor in post-war traffic increases, provided that we lick the problem of airport accessibility. Within a decade, we should see about 20 million airplane passengers a year, or five times the 1941 number." *Charles I. Stanton, Administrator of Civil Aeronautics.*

" " "

"A LARGE VOLUME of construction ready to start instantly, may be the very thing that can prevent initial post-war unemployment from spiralling downward into a major depression." Major General Philip B. Fleming, Administrator, Federal Works Agency.

AVIATION

Conducted by ALEXANDER KLEMIN



Dr. Elizabeth Newkom, left, records data in the stratosphere chamber

Bringing Down The Stratosphere

In the Sperry Gyroscope Company's New High-Altitude Laboratory Conditions of Low Pressure, Extreme Cold, and Oxygen Lack are Duplicated by Means of Vacuum and Other Equipment, Affording a Peculiar Kind of Research that Combines Aeronautical Engineering, Physics, and Physiology

MAN IS splendidly equipped for life at sea level, at the bottom of a deep ocean of air. His lungs work effectively at the concentration of oxygen produced by this tall air column, the composition of the atmosphere suits him admirably, and the temperature almost anywhere on the surface of the earth permits life without too great discomfort. But man cannot stand the extreme cold, the low air pressure, and the lack of oxygen which are encountered at great altitudes. The problem of altitude is one of the utmost importance in military aviation, particularly for the pilots of the single-seater fighters or medium sized interceptors which are too small to permit the construction of a pressurized cabin. An important research of the day is therefore concerned with the physiology of high-altitude flight, and the behaviour of instruments and equipment under severe altitude conditions.

In such research there has been developed an altitude-chamber technique which calls for the combined talents of the aeronautical engineer and the medical man. The Vose Memorial High-Altitude Laboratory, recently completed by the Sperry Gyroscope Company, is the most recent and perhaps the most fully equipped of the laboratories dedicated to this type of research.

The work of such a laboratory cannot be fully appreciated without reviewing briefly such matters as the properties of the atmosphere, the elementary physiology of breathing, and the perils and difficulties of anoxia, or shortage of oxygen. Besides a number of severely technical works, we are indebted to Herbert S. Zin's fine book, semi-popular, semi-technical in character, "Man in the Air."

REDUCED PRESSURE—At sea level the pressure of the air is equivalent to that of a column of mercury 29.92 inches high, or 14.7 pounds a square inch. Such figures constitute an enormous load and the reason man can withstand such loads is because he endures the same balancing pressure within his body as externally. With altitude the pressure drops—very rapidly at first, more slowly at great heights Thus, at 8000 feet, the pressure is three quarters that of sea level, at 18,000 one half, and at 50,000 only one tenth that of sea level.

The distribution of the gases in the air at sea level is surprisingly uniform, winter and summer, pole and equator. The atmosphere is a physical mixture containing about 78 percent of nitrogen, 20.95 percent of oxygen, 0.09 percent of carbon dioxide. It also holds a small amount of water vapor, which is essential to our well-being. The carbon dioxide is not harmful in small quantities; it stimulates breathing and controls normal respiration. The oxygen is an essential element of life, since it produces oxidation of foodstuffs in the cells of the body and liberates heat. Without the beneficient action of oxygen, life is impossible. The nitrogen has little effect besides diluting the oxygen, but the dilution is highly important. Nitrogen, like oxygen, is dissolved in body fluids and in the blood. It is not readily released, but when it is released rapidly it becomes a menace. At sea level the oxygen alone has a pressure of 160 millimeters (compared with the total pressure of the air of 760 millimeters); at 20,000 feet the oxygen pressure is only 73 millimeters. Thus altitude brings a smaller amount of oxygen in each breath, and at the same time

the oxygen there is less capable of doing its work of penetrating through the lining of the lungs to feed the capillaries of the body.

SIXTY SEVEN BELOW ZERO—The temperature also drops, with altitude, about one degree, Fahrenheit, for every 300 feet. When the division between troposphere and stratosphere is reached, at around 35,000 feet, the temperature is lowered to —67 degrees, Fahrenheit, and stays constant thereafter, at least for any altitude with which we are likely to be concerned for many years to come

Man's adjustment to the lower temperatures of high-altitude flying is well understood. Cold can be met by hot food, warm clothing, and, to a certain extent, by exercise. But lack of oxygen calls for further discussion Temporary adjustment is possible by the healthy pilot up to 18,000 and even 20,000 feet. At higher levels he loses consciousness unless artificial means of supplying oxygen are provided. The first symptoms of anoxia occur at about 8000 feet and are dangerous and insidious, because the victim may feel more confident and capable than usual, suffering from something like an alcoholic jag at a certain stage of its development.

The process of breathing is an unconscious one, and is explainable in physical terms The oxygen, when introduced into the lungs, passes through the thin tissues of their air sacs and subdivides into the 25,000,000 tubes of the bronchial system, each tube ending in a dozen or more rounded sacs known as alveoli. These 400,000,000 sacs are arranged like bunches of grapes. The oxygen, with its higher pressure, passes into the thin walls. carbon dioxide, with a lesser pressure, moves in the opposite directions.

Even after exhaling the lungs still contain six to seven pints of air, which is known as alveolar air. The one pint of air which is taken it at each breath mixes with the alveolar residue

What now happens when there is less oxygen to breathe, and the oxygen, with its lower pressure, loses its penetrating ability? Pulse rate and rate of breathing definitely increase, vision is not so keen, sounds seem faint and far away. Symptoms of anoxia are cumulative and continued exposure makes matters worse. At 25,000 feet the pilot will feel serious effects in 15 seconds Consciousness will be lost soon thereafter. Pilots flying in formation who do not use their oxygen masks correctly have been known to do the most unaccountable things in the early stages of anoxia—they may break formation or even attempt to machine-gun their own friends

There have been almost innumerable designs for oxygen equipment. At one time liquid oxygen—compact, easy to handle, but dangerous—was used It was soon abandoned. Gaseous oxygen has proved far more practicable for aviation use Yet, when carried as compressed gas in alloy-steel cylinders, it offers another danger—loss under the impact of enemy bullets. For this reason, oxygen is generally carried today in a number of low-pressure tanks

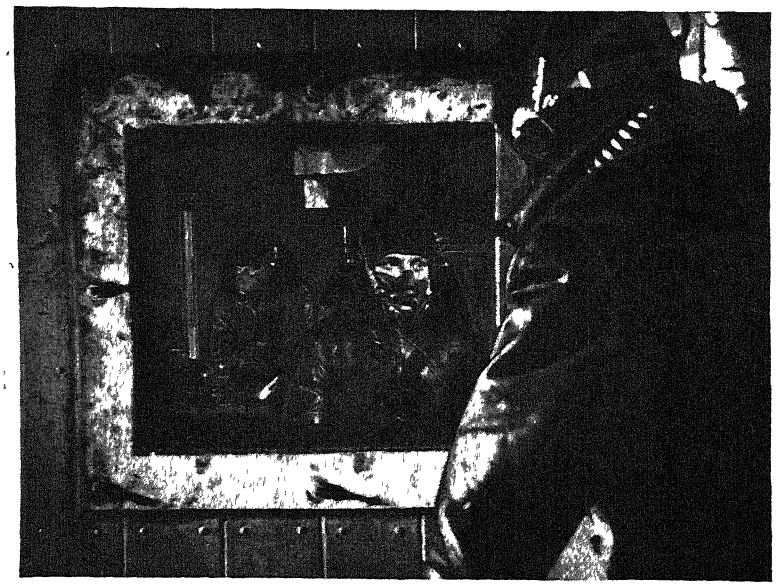
Oxygen equipment having rubber tubes or pipe stems for taking oxygen into the mouth has been tried but the process proved uncomfortable and painful. Masks have been found far more efficient. Theoretically, rebreather masks are most desirable, since they are so economical of oxygen, but they are bulky and require a perfectly airtight mask. Finally, the air services of all nations have agreed upon the demand type of mask, in which the flow of oxygen is regulated by the very breathing of the pilot. This mask fits tightly over the mouth and nose. A sponge-rubber valve and a rubber bag form the essential elements. A rubber tube from the oxygen supply line fits inside the reservoir so that the steady flow of oxygen enters and mixes with the air already present. The rate of flow is controllable by the pilot

One more physiological consideration of high-altitude flight is aeroembolism, "the bends." Our blood contains dissolved nitrogen and so does the body. Rapid ascent into low-pressure altitudes causes nitrogen and carbon dioxide to dissolve out of the body and form minute bubbles. These bubbles may block circulation of the blood, press on the nerves, cause terrible pains, and produce injury and even death

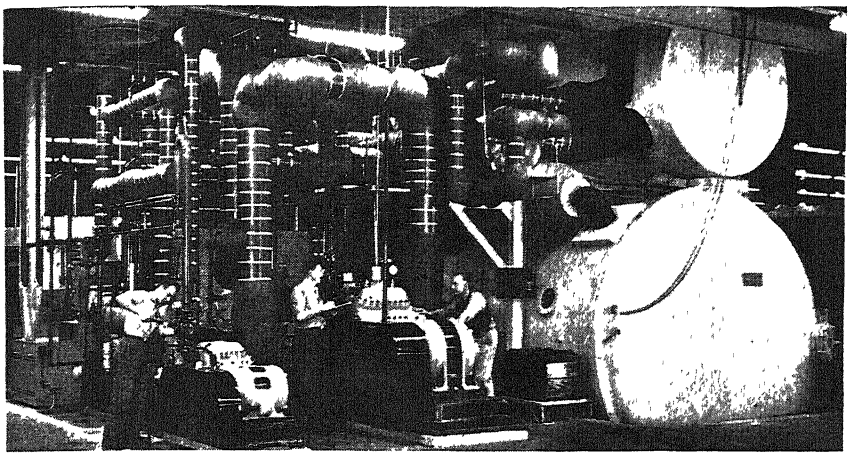
Pressurized cabins avoid all these difficulties, and they can be and have been built with great success in air liners and high-altitude bombers Pressurized suits have also been developed Wiley Post used one in a number of his cross-country flights Using pressurized suits the British have flown to over 53,000 feet Pressurized suits have used a combination of artificial increase in pressure and artificial supply of oxygen Yet all the mechanical difficulties have not been solved, and the pilot encased in a pressurized suit becomes so bulky and heavy that his military potential is lessened

WHAT THEY ACCOMPLISH—The purposes of high-altitude laboratories now become abundantly clear They are used to study electrically heated suits and gloves. They serve to do research on such vital equipment as air-speed indicators, artificial horizons, the automatic pilot. They give us a vast amount of information on the physiology of the flier. They show us how to train pilots for maximum endurance under high-altitude conditions, and how to select those who may safely subject their bodies to the strains of the stratosphere And, finally, they teach us how to circumvent high-altitude effects by oxygen masks, by ridding the blood of nitrogen before a flight, and in many other ways.

The new Sperry laboratory is appropriately dedicated to the memory of the late Frederic Blin Vose who, after active service in the Navy, served the Sperry Gyroscope Company in sales engineering and instrument development, was the first American civilian to fly with the RAF over Germany, did much to further precision bombing, and lost his life in an airplane crash on May 1, 1942.



Experimenters in the high-altitude chamber are under constant observation for reasons of safety as well as of research. The illustration at the left is taken from within the air lock at the end of the chamber and shows an observer watching the workers through a window. At the right is Dr. Zand outside the chamber, but in telephonic communication with the workers



The stratosphere chamber is at the lower right, while the refrigerating and dehumidifying equipment, with its attendant coils, pipes, and pumps, is at the left

In the Vose Memorial Laboratory, high-altitude conditions have been duplicated on the ground by means of an insulated steel shell equipped with vacuum pumps for varying the atmospheric pressure inside the shell to a point as low as that existing at 60,000 feet. Refrigeration equipment makes it possible to maintain a temperature of —75 degrees, Fahrenheit, with an air bleed out of the shell of 10 cubic feet a minute. The main test chamber is 16 feet long and 12 feet in diameter. Welded on to one end is a lock chamber eight feet long and eight feet in diameter

DR. ZAND'S DESIGN—The basic design of the laboratory is due to its Director, Dr. Stephen J. Zand, who has to his credit outstanding achievements in many fields of applied science, in the design of gun turrets, in the development of gun sights, in the sound-proofing of the airplane, in the development of the gyroscopic pilot and, last but not least, in high-altitude research. The strength of the Vose Memorial Laboratory lies in the excellent basic design, the foresight which makes its operation so safe (for example, air can be introduced into the chamber simply and rapidly whenever this seems desirable, and communication between personnel in the chamber and outside the chamber is always maintained), in the completeness of accessory equipment and experimentation, and, above all, in the enthusiasm and skill of the workers in the laboratory.

The accompanying photographs convey a conception of the structure of the laboratory and of its work. In one picture is shown the huge stratosphere tank, with the coils, pipes, and pumps which constitute the refrigeration and dehumidifying equipment. This equipment occupies more space than the high-altitude tank itself and involves a fine application of air-conditioning engineering.

For the sake of safety, workers within the tank are under constant observation from outside. Another of the photographs shows the observer standing in the sealed lock in which the pressure is somewhat higher than inside the actual altitude tank. Should anything go wrong with his co-workers at the higher altitude, the observer can open the heavy door and enter quickly and safely. There is an added element of safety in the fact that Dr. Zand, also acting as observer, can watch the whole course of a test from the open air and take dictated notes, through a portable telephone, from the men inside.

It is one of the most fascinating aspects of the laboratory that it combines engineering and physics with medicine and the study of the human body, and it is a sign of the times that the medical supervisor, Dr. Elizabeth Newkom, is a woman. In another of the illustrations, Dr Newkom is taking data from Irving Hilliard, an aeronautical engineer, who is adjusting a Sperry automatic pilot

When workers prepare to enter the tank they must be equipped to withstand intense cold. They therefore don the warmest possible underclothing, which is supplemented by heavy electrically heated outer suits.

Every science is drawn into service in the work of the laboratory. For example, in testing oxygen masks a hypodermic needle is inserted through the soft rubber of the mask to withdraw a sample of breath for a test which reveals instantly if any air has leaked in to become mixed with the pure oxygen. Again, a photoelectric cell mounted near the lobe of the ear measures its transparency to light and thus serves as a check on the oxygen content of the blood.

In yet another phase of the work, an experimenter, completely equipped for ascent to the stratosphere, but prior to entering the chamber, breathes pure oxygen and pedals on an electric "bicycle" for 15 to 30 minutes until the nitrogen vanishes from his blood. This prevents the possibility of aeroembolism in rapid ascent.

Obviously, work of this kind is not open to every man or woman. A severe physical examination is given to anyone before he or she is allowed to make an oxygen-mask ascent in the chamber. But it is only through such work that the secrets of high-altitude flying are being unfolded. Laboratories of this kind, intelligently applied to the solution of practical problems, will do much to further the cause of stratosphere flight in the future.

+ + +

FOUR MINUS TWO

Engines Bring a Fortress Home

THE FLYING FORTRESS has proved to have remarkable powers in bringing home its crew after severe hammering. Bomber pilots have landed their ships in England with tails partially shot away, with the fuselage riddled with bullets. Some of them have limped back with only two of the four engines still functioning. In our remarkable photograph of the B-17, the latest type of fortress, it can be seen that the two port engines (left side, to the uninitiated) are stilled and the propellers feathered. Feathered means that the blades are turned directly into the wind so that they produce the least air resistance and the least vibration

TRAFFIC CONTROL

Projected for Post-War Airways

MOST optimistic as to the post-war future of aviation is Charles Stanton, Administrator of the Civil Aeronautics Administration, who, in his annual review, forecasts a great expansion of both scheduled and private flying. The C.A.A intends to keep abreast of such

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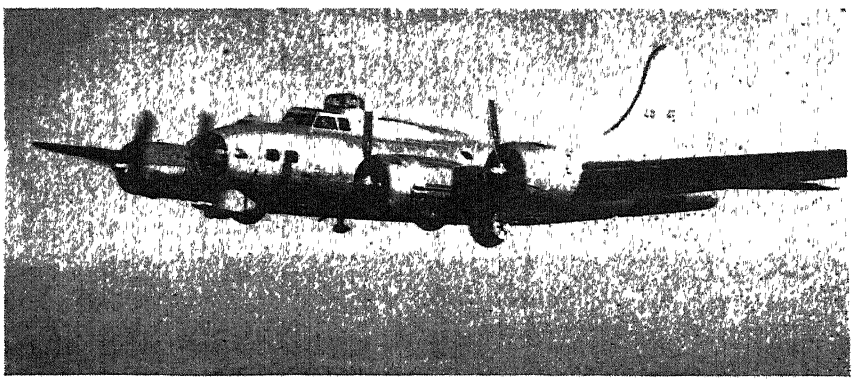


Limping home on only two engines, but getting there just the same

Supersonics at Work

Inaudible Wave Power is Being Used Today to Detect Flaws and Deviations in Manufactured Products, to Measure Underwater Depths and Distances, and to Detect Underwater Objects such as Fish. Principles Have Been Developed Which Have Interesting Possibilities for Future Expansion

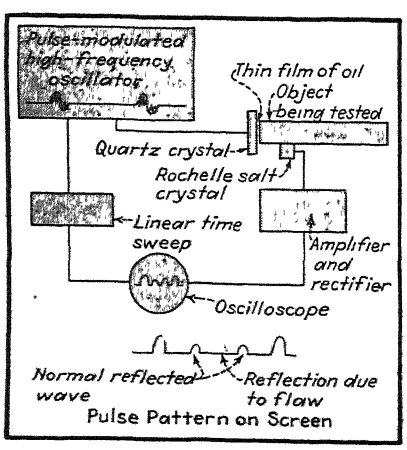
IN MANY war plants, workers may be seen tapping objects, one after another, in front of a microphone. Little or no sound can be heard by human ears, yet every now and then a light flashes and the operator tosses a piece aside as defective.

This is just one of several new techniques which utilizes supersonic frequencies for inspection purposes in industry. Cracks, differences in hardness, changes in dimensions, and variations in the composition of many materials can be quickly detected by this method

The story behind these new supersonic developments dates back to prewar days when research engineers of the Vendo Company were concentrating on the problem of detecting slugs inserted in their coin-operated beverage vending machines. One method proposed for slug detection was measurement of the sound frequencies given off by various coins as they entered the machine and bounced back and forth.

Experiments on specimens of various metals, made into slugs of the same dimensions as genuine coins, indicated that those slug metals having a lower modulus of elasticity than metals in genuine coins would vibrate at lower frequency. A band-pass circuit of about 200 cycles was found to be necessary because variations in thickness of genuine coins due to wear required some latitude in the detection apparatus A few models of slug ejectors using this principle of operation were constructed and tested, but development work was suspended at the start of the war. Electronic research and development facilities of the company were then utilized to develop instruments for inspection of the thousands of parts which were produced for the various branches of the armed service. Supersonic experiments were conducted on small items such as bullet cores, steel punches, and small caliber cartridge cases

In one method of utilizing sound waves for the inspection of materials, standard specimens are set into vibration and their tones measured to determine the permissible range of tone frequencies. Each piece being tested is then similarly vibrated and its tone checked with electronic instruments or by ear when the items are of such dimensions that the frequency of vibration is audible. Any appreciable difference in tone indicates a flaw This method is now in use by various industries for testing files, grinding stones, and castings.



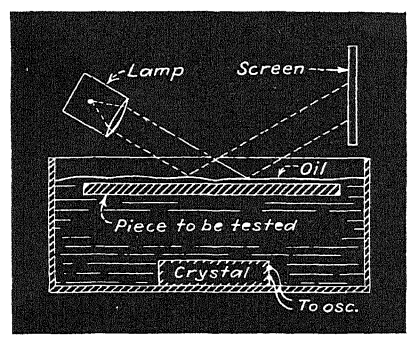
Flaw detection by observation of reflected supersonic waves. Flaws in the object under test show up as extra pulses in the 'scope pattern

HETERODYNE PRINCIPLE USED—When the frequency of vibration extends above the audible range (above 20,000 cycles), an instrument called an audio-heterodyne amplifier is used for making the sounds audible. The circuit consists of an amplifier in which is contained a local oscillator that beats with the incoming frequency to produce a difference frequency that falls in the audio range. This is similar to the superheterodyne principle used in communications.

A satisfactory microphone for picking up supersonic frequencies is a type of crystal cell manufactured by The Brush Development Laboratories. This cell is made from rochelle salt crystals cut to resonate at definite frequencies. Other types of microphones can also be used if the moving element is stretched sufficiently to resonate at the desired supersonic frequency.

The types of flaw which produce deviations from normal frequency in an article are cracks, a change in hardness, changes in dimensions, and changes in composition

When an article is found which can be tested by measuring its vibration frequency, several good samples are procured and a frequency test is made by striking the article on a hard surface, allowing it to vibrate freely, and picking up and tabulating the sound frequencies. The tabulated frequencies are then analyzed and the band widths established. Some band-width latitude is necessary because of small variations in dimensions in the articles.



Flaw detection by immersing test piece in oil and sending a supersonic beam through it. Amount of light reflected from surface of oil is proportional to amount of supersonic energy passed by the test piece

Next, the production test instrument is constructed. It is designed to pick out any article which does not have the same vibration characteristics as the standard articles, regardless of whether the sound can or cannot be heard.

In the circuit employed for this purpose by Boley A. Andrews of the Vendo Company, the output current of the microphone is amplified by a preamplifier tube, fed through a limiter tube that cuts off undesired strong signal peaks, amplified some more in a broadly tuned amplifier stage, then fed into a harmonic generator tube that greatly distorts signals exceeding a certain level, so as to produce many higher harmonics of the signals. The harmonics which pass through the following 175-kilocycle transformer are fed through a conventional intermediate frequency amplifier stage to a diode detector that provides a D.C voltage for operating a trigger tube. This trigger can be used to close an alarm circuit, turn on a red lamp, or

operate automatic rejection apparatus when the supersonic frequency goes above or below the permissible limits

The purpose of the tuned amplifier is to allow only those frequencies which are in the prescribed band width to reach an amplitude great enough to operate the harmonic generator.

A typical requirement might be a band width of 100 cycles peaked at 19,500 cycles. The bias supply on the harmonic generator is set so that only those frequencies which are less than about 200 cycles away on each side of the peak voltage will produce harmonics. Thus, harmonics are generated of these acceptable frequencies only. The 9th harmonic of 19,500 cycles is 175.5 kilocycles, which is in the tuning range of standard intermediate-frequency transformers.

The instrument can be adjusted to any frequency merely by changing the microphone and the tuned coil used in the amplifier stage preceding the harmonic generator. The intermediate-frequency stage can remain the same, selecting different multiples of the fundamental frequencies so as to be within the tuning range of the coils.

DURATION OF SOUND—A second method of flaw detection by supersonics involves measuring the duration of sound given off by an article when in free vibration. This system is now being used in its elementary form for testing glasses and goblets. It is also used for testing the bond between two pieces of metals, as in steel-backed bronze bearings. In these applications, the testing is all done by the ear, and the article is struck or dropped to produce vibrations.

When an object is set into free vibration, the amplitudes of these vibrations decrease exponentially. This is due to internal friction of the object and is known as the damping property of vibration.

The specific damping capacity may be determined by measuring the logarithmic decrement of vibration. This can be obtained by vibrating the object first at its natural frequency, than at frequencies on each side of the peak frequency, and noting the amplitudes.

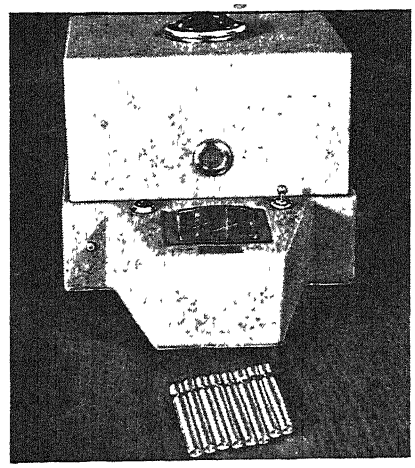
The apparatus required for this type of test includes an audio oscillator, a vibrator, an oscilloscope, and a vacuum-tube voltmeter. The standard specimens are first tested and the decrement noted. Any object that produces a different value of decrement is rejected.

A third method used in supersonic testing is that in which the supersonic wave is actually passed through the piece to be tested and the resultant reflection or absorption of waves measured. This method is more precise than the two previously mentioned systems, but is more involved and requires a larger amount of apparatus.

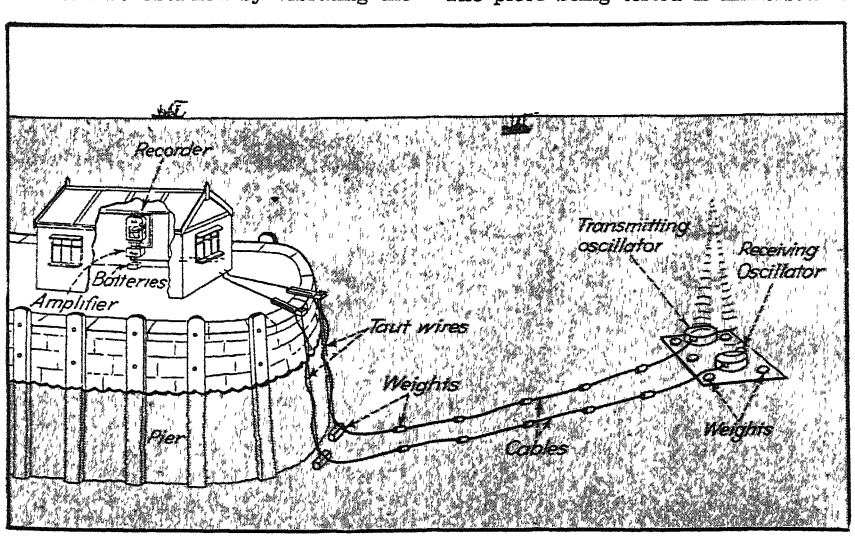
The object being tested is mounted on a suitable support, and a quartz crystal is attached to one end of the test specimen, as shown in one of the illustrations. This crystal is connected to a high-frequency oscillator that is pulse-modulated by a low-frequency oscillator. A rochelle salt crystal for picking up the pulses is also attached to the specimen. This crystal is connected through an amplifier and rectifier to a cathode-ray oscilloscope for visual observation of the reflected waves traveling along the test specimen.

The test is conducted first on several standard specimens, and the reflected waves are noted on the oscilloscope screen. The pattern is a series of reflected pulses which occur at frequent regular intervals when the specimen is flawless. If a flow exists, there will be in the pattern an extra pulse which is not obtained with a good specimen, this is indicated by the dash-dash curve in the illustrated pulse pattern.

In a variation of this method, a quartz crystal which is connected to a supersonic-frequency oscillator is submerged in a pool of oil. The crystal will send sound waves vertically upward in a beam. At the point where the beam hits the surface of the oil, a light ray is focused and is reflected on a screen. The piece being tested is immersed in the oil and placed in the sound beam, and the variations in the intensity of the reflected light on the screen are used as an indication of the quality of the specimen being tested. This method was used experimentally by Sokologg of U.S.S.R. in 1934. More recently, it has been tried for inspecting tires immersed in a tank of water. It was hoped that any change in the transmissibility of supersonic waves through the tire as it was slowly revolved in the tank would indicate the presence of flaws, but early results proved discouraging. Small flaws such as air bubbles did not change the absorption sufficiently to permit detection, but post-war research may well solve the problem and even put supersonic tire-testers in every garage



Supersonic instrument developed by the Vendo Company for inspecting steel punches. Punches are tapped on the anvil just under the grille protecting the crystal microphone. If the supersonic vibration frequency of a punch is outside the predetermined wave band, indicator lamp is automatically turned on



Supersonic harbor tide-recorder. Both oscillators are on ocean bottom, and the supersonic waves traveling through the water are reflected downward from the water-air junction. Associated equipment measures the time required for the wave to travel from bottom to surface to bottom, converts this data into measurement of the tide level, and records the result on paper tape at regular intervals

WAVE GENERATION—Many methods of generating supersonic waves have been developed. Perhaps the commonest is an oscillating quartz crystal in a vacuum-tube circuit initially developed by G. W. Pierce. A piezo-electric source was developed by the French physicist Langevin for transmission of waves up to 50 kilocycles in sea water for subaqueous signalling. An oscillator making use of the magnetostriction properties of such materials as nickel or iron-nickel alloys is cheap and easy to build but has a practical upper frequency limit of about 60 kilocycles when appreciable amounts of power are required. The Galton whistle can be designed to produce frequencies as high as 100 kilocycles, and is usually built with a micrometer screw adjustment of pitch. Finally, the Holtzmann mechanical supersonic generator uses a glass tube clamped at its center and set into oscillation by friction of two moving silk-covered leather belts.

Some of the most striking experimental results obtainable with supersonic waves depend on the relatively large amount of power which is associated with supersonic waves of moderate amplitude. Waves have been gen-

erated in an oil bath by using a piezo-electric quartz crystal at 50,000 volts and a frequency of about 300 kilocycles A radiation pressure estimated to be equal to 150 grams was obtained —enough to raise the free surface of the oil into a mound seven centimeters high.

Without especially large vibrations, it is possible to transmit enough supersonic energy through a small rod so that a painful burn is obtained if the rod is squeezed with the fingers. Another direct application of supersonic energy is in making unusual and very fine emulsions.

Reflectors of convenient dimensions may be used to focus supersonic energy or reflect it from a point source such as the end of a magnetostriction rod Whereas with audible frequencies it is difficult to limit echoes and unwanted reverberations, with supersonic waves the apparatus is small and the reflections can be easily handled.

An immediate demonstration of the realness of the elastic waves that travel through a liquid excited by a supersonic source is furnished by a change in the optical properties of a liquid which is so disturbed. Points along the wave at which the medium is most compressed may become nearly opaque The presence of the supersonic waves causes the liquid to act like a diffraction grating and the light is diffracted into its characteristic spectrum.

DISTANCE MEASURING—The transmission of sound waves through water for distance-measuring purposes is not new. Lighthouses equipped with radio transmitters and submerged hydrophones frequently send simultaneous radio and sound signals to ships at sea The radio signal arrives almost instantaneously, while the underwater sound signal travels at the approximate rate of 4800 feet a second in salt water By measuring the time interval between reception of radio and sound signals, the ship's officer may readily calculate his distance from the shore station.

In a similar manner, a ship can transmit a sound signal downward to the sea bottom and measure the time between transmission of signal and reception of the echo reflected from the bottom. Supersonic waves could just as well be used for this purpose In any event, the time interval is very small, a tiny fraction of a second, and its method of measurement must consequently be fairly precise.

Sonic methods of sounding have been in use for a number of years, but the equipment has been relatively complicated. Recent advances in design, utilization of electronic equipment, and successful employment of supersonic waves have brought the equipment into quite general use in at least one European country, not only for sounding but also for detecting underwater objects. Large fishing boats equipped with these electronic fathometers have been able to detect schools of fish swimming many fathoms under water, and increased hauls have undoubtedly quickly paid for the extra equipment.

The complete story of new supersonic applications for use in industry and at sea must wait until restrictions of military secrecy are lifted, but here as in other fields of electronics the future possibilities are bright With applications already ranging from slug-detectors to fish-finders, the list of possible future applications promises to be quite long and interesting.

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HIGH-SPEED SOLDERING

Accomplished Safely With Radio-Frequency Heat

SMALL metal containers used for capacitors are being soldered with radio-frequency power at the rate of 2500 units per hour per operator. The containers, with bottoms and rings of solder in place, are carried by a moving belt through an applicator coil where localized heating induced in the metal causes the solder to flow and seals the bottoms without endangering the capacitor.

AREA MEASURER

Makes Use of an Electronic Calculator

AN ELECTRONIC instrument for measuring areas of flat sections of material is now in use for determining the size of leather hides in the leather industry and for measuring pattern layouts in the textile industry. Other possible applications include measurements of the area of ink on printed matter and measuring the surface enclosed by pinpricks on perforated layouts and outlines.

The hide or other object to be measured is inserted between rollers that transport it through the machine developed by the Stockton Profile Gauge Corporation. Extending parallel to the axes of the rollers is a long narrow slot. As the skin passes across this slot it comes into the path of a scanning beam of light that travels back and forth in the slot.

Since the rate of movement of the beam and the rate of feed of the skin are known, the area of the skin can readily be calculated, when the total time interval during which the beam is on the skin is found by the phototube system.

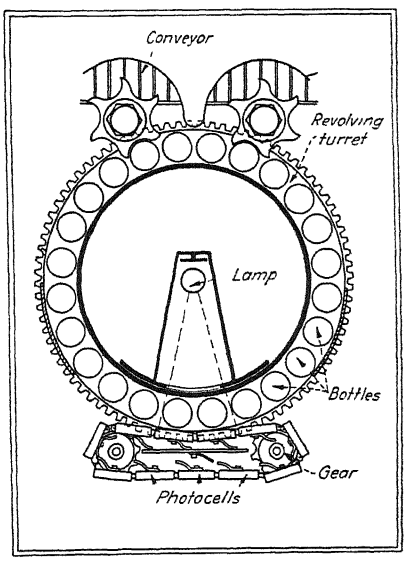
The area of the skin is calculated electronically. Phototubes are positioned above the skin to pick up reflected light, or under the skin to pick up transmitted light, depending on which arrangement gives the greatest change in light when the beam moves onto the skin. Electron-tube amplifiers and indicator lamps provide five electronic-counter visual columns of ten counts each. The numbered lamps flash on progressively from the top of a column as each impulse is received from the photo-electrical equipment in the scanning machine.

Many uses are possible for such a high-speed counter. For example, the speed of missiles could be determined to one fourteen-thousandth of a second by having the missile pass through two loops spaced a definite distance apart. One loop would start to count pulses from a fixed-frequency generator at a predetermined rate, and the second loop would stop the count when the missile passed through.

BOTTLE INSPECTION

Speeded Up by Use of Photocells

PHOTOTUBES have been used for several years for the detection of foreign ingredients in the bottling of soft drinks A modified and faster system that contains a number of photocells mounted on a roller chain has been designed for the Coca-Cola Company by George P. Stout.



Moving a series of photocells in synchronism with objects being electronically checked, as exemplified by the bottle-contents inspection set-up illustrated, is a scheme that may well be applied, with variations, to other practices, where speed and accuracy are requisites

The roller chain carrying the photocells is driven by teeth positioned around the outside edge of the revolving turret carrying the bottles. As the turret revolves, the teeth engage the roller chain so that bottles adjacent to the teeth travel in synchronized relationship with individual photocells for the necessary interval during the inspection period. When a bottle becomes alined with a photocell, the beam of light from a lamp passes through the whirling contents of the bottle onto the cell. If the beam is interrupted by a foreign particle in the bottle, this change is registered by the cell. The resulting electrical impulse is amplified by electronic means and caused to operate a mechanical method of rejecting the objectionable container

Insects Can Be Controlled

New Weapons and New Methods of Using Them Have Been Developed by the Chemical Industry. Many of these Have Great Potentialities in the Commercialization of Disease-Ridden Areas Where Insects Have Formerly Prevented Human Exploitation of Rich Natural Resources

By-victories of this global war will do things to and for us long after victories on the field of battle are forgotten Along with the struggle against the human enemies goes another less publicized but no less fateful war in test tubes and garden plots against our insect enemies That war, too, moves swiftly to new victories, promises new freedom from disease, and new fruitfulness for farms, orchards, and vineyards.

Miracles in curing disease in this war year parallel important successes in its prevention. The nature of the conflict has taken armies and navies into unaccustomed places where strange insects carry dread diseases. Our men must be protected from insects as well as from human foes lest the disease records of old wars be repeated now on a much grander scale. To insure this protection we have developed new weapons and new and more effective techniques for using them. This secondary war of chemists and entomologists has already chalked up victories of its own, significant alike to the armed services in the field and to generations to come. Mosquitoes, body lice, and a host of other disease-bearing insects face new weapons of unprecedented power in the future. Other insects, which in devouring hordes have eaten or destroyed the produce of our farms, also face destruction by new weapons, by-products of war.

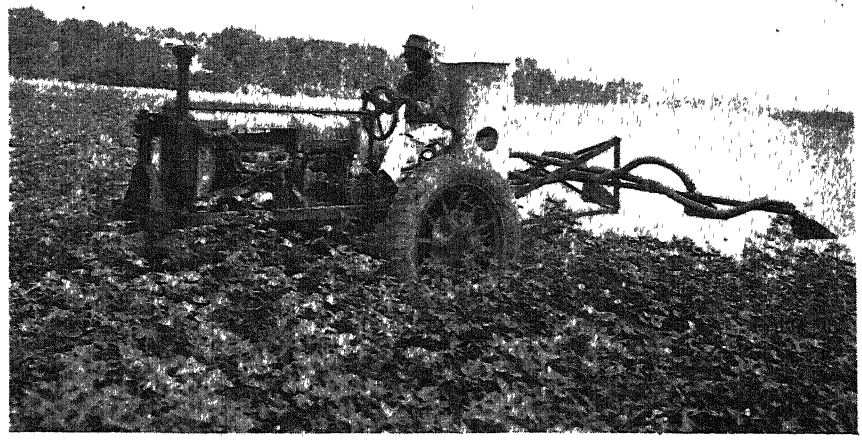
One can scarcely over-estimate the significance of new preventive measures developed in the fight against insects. The familiar historical example is the building the Panama Canal by exterminating the mosquito that carries yellow fever. This great extermination project involved an engineering enterprise too great to be repeated today in all the myriad small islands of the Pacific, the jungles of Africa and Asia, or the slums of great cities. Yet the need now is much greater. Modern swift transportation by air brings all the pest-ridden areas of the world within a few hours of dense centers of population and thus exposes everyone to all the world's diseases by the chance inclusion in any cargo of disease-bearing insects. In this increasingly grave situation the need for effective means to combat plague carriers is clearly pressing.

Vast areas of fertile soil and fruitful climate are prohibited to man by well-established insect families carrying diseases. Areas of Africa in which sleeping sickness (trypanisomiasis) forbids human exploitation are among the richest in the world agriculturally and mineralogically; yet the tsetse fly which carries the disease flourishes there in such abundance that men cannot survive. Similar areas elsewhere are so malaria-ridden as to be equally impossible of human development. The great potentialities of these regions suggest that the conquest of these diseases may well have an effect on the future human welfare equalling or even surpassing that of the discoveries of all the explorers of the Renaissance. Much of that promise seems now to be on the brink of realization

COMBINED EFFECTS—No single discovery or development will achieve the whole result, but the combined effects of several, now awaiting the end of hostilities to go into action, promise much in that direction. Curative medicine is making vast strides, but prevention also keeps pace. It is worth while in the light of these global problems to look into insecticides as preventives. Their probable effects on the future standard of living are vital in countries now backward in their development because of insects and insect-borne diseases.

One of the most important results of this war is the proof that it is giving people everywhere that insects can be conquered, that the diseases they carry are far from inescapable. The materials and methods used in this fight against insects and disease have undergone extraordinary development under war's impetus and we, already accustomed to the use of insecticides, are in for some important surprises at war's end.

Certain insecticides in mixtures of two or more substances have been shown to accomplish substantially more than either alone or than the expected sum of the actions of the two together. This action, called synergy, finds amazing demonstration in some of the substitutions and economies undertaken as makeshifts to offset war-created shortages. The basic fact that mixtures are sometimes more effective than single materials is not new. Many years ago the convenience of mixing



Dusting a southern cotton field to protect it against boll weevil

intensely cold dry-ice with highly volatile ethylene oxide was discovered to be a more convenient means of introducing the latter into grain elevators to kill weevils. Actually the mixture is more effective than ethylene oxide alone, even though carbon dioxide alone is relatively ineffective. But the explanation was long considered to lie in the low temperature of application which prevented dissipation and loss of the toxic ethylene oxide. Recent discovery of other similar cases of extraordinary action of mixtures has led to a search for more cases with new vigor. The name, synergy, borrowed from medical terminology, signifies working together and defines actions where two and two make five or more instead of the usual four. The whole category of insecticides is being reexamined to find new similar ways to stretch the effectiveness of limited supplies of many of these valuable agents now available.

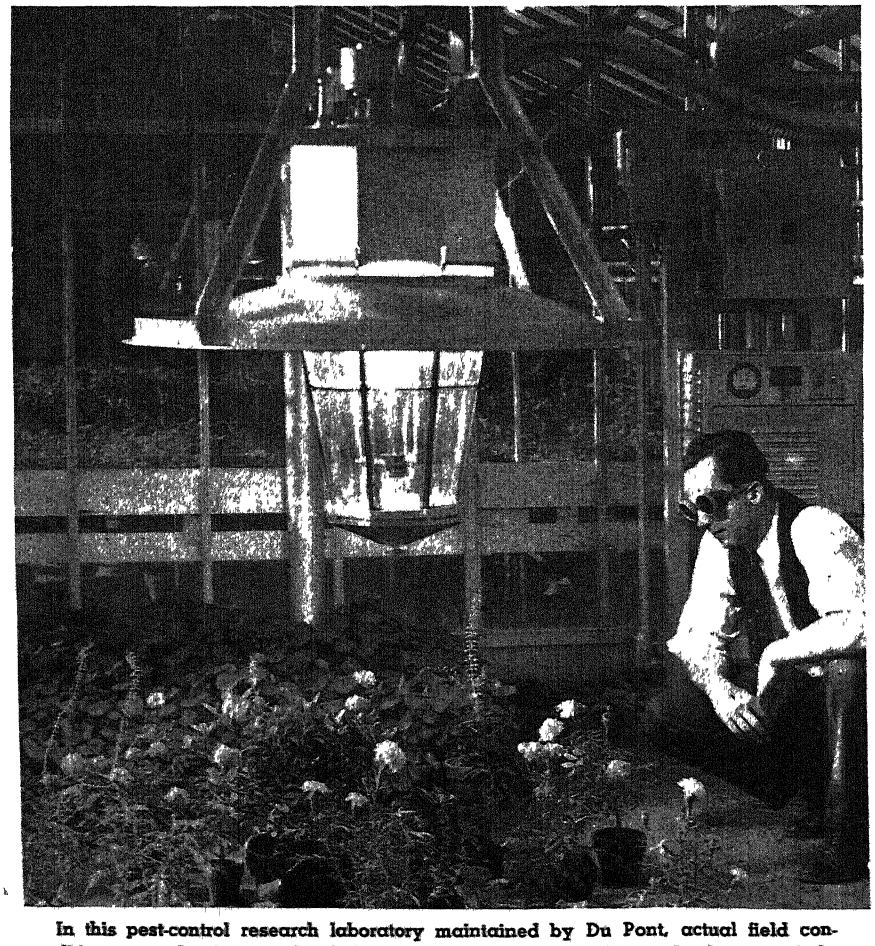
And not without significant successes. Pyrethrum flowers, formerly grown principally in Japan, supply one of our most effective common insecticides The extract of pyrethrum, pyrethrin, is highly toxic to insects but relatively harmless to man, and hence is the basis of common fly sprays and like materials. But the flowers were and are stringently scarce and every means possible has had to be sought to conserve and to stretch our meager supply. Sesame oil, expressed from the sesame seeds, produces a remarkable increase in the effectiveness of pyrethrin and allows smaller concentrations to be used without reduction of killing power. That gave the seekers for synergies new hope and led to the discovery that this action of sesame oil is quite general. Further investigations brought to light a series of synergetic actions of other insecticides, until present informed opinion looks primarily to this phenomenon as vital in devising new weapons against our insect foes. Several of the new synthetic insecticides and insect repellents discussed below possess strong synergetic action as one of their important values

BOMBS AGAINST INSECTS—Much attention has also been given the aerosol bomb as a method of distributing insect-killing products more effectively than ever before. In principle, this consists of a solution of the insecticide in a liquid so volatile that it can be kept liquid only under pressure. When the outlet of the steel cylinder containing the solution is opened, the solution rushes out under pressure and evaporates instantly as it reaches the lower pressure of the atmosphere. This has the very desirable effect of blasting the dissolved insecticide into droplets far finer than can be produced by any atomizer of the usual type. The size of the infinitesimal droplets is so small that they behave almost as a gas and diffuse with great speed and thoroughness into all parts of the enclosure in which they are thus released. Since the dose of insecticide required to kill a single insect is also infinitesimally minute, this method of super-atomizing the killing mixture is especially effective and stretches the available supplies of scarce insecticides far beyond their usual range. The solvent used is dichloro-difluoro-methane, familiar as Freon in the electric refrigerator, chosen for this purpose because it is non-toxic and non-flammable. The most common insecticide dissolved in Freon in the bomb is a synergetic mixture of pyrethrin and sesame oil. However, the method can be equally well applied to others, including DDT discussed further below.

Delousing clothing of soldiers, a ponderous operation as conducted in World War I, when great steam sterilizers were employed, has been greatly simplified Methyl bromide, long used against weevils in grain elevators, has proved to be effective also against "cooties" and its use requires a minimum of equipment The clothing to be freed of insects is put into a closed gas-proofed bag and methyl bromide, which evaporates readily, is released in the bag as a gas by merely breaking a small glass ampoule containing it under pressure Insects are killed in short order.

Most discussed of the new compounds risen to prominence in war service is dichloro-diphenyl-trichlororethane, shortened to DDT for obvious reasons, but also called Gesarol. This compound has remarkable power to kill insects, particularly body lice—the "cooties" of World War I. Prevalence of typhus, carried by body lice, in the Mediterranean theater of this war has emphasized its value. Clothing dusted with DDT powder is immediately freed of lice and retains this killing power over a considerable period of time. DDT's effectiveness now in war may well be overshadowed by its value, as yet unutilized, in peace. Painstaking investigations conducted by the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture have shown it to be signally effective against many of the most destructive insects that feed upon the growing crops of our farms. And that is important. Insects eat and destroy something like two billion dollars worth of crops annually in the United States alone. In controlling these pests, the effectiveness of DDT has proved to be so great that entomologists are already counselling caution. Its general use, they fear, may destroy friendly insects as well as destructive ones, bees as well as boll weevils.

THREE IN A MIXTURE—Three other important additions to our weapons against insects have come into special prominence. Dimethyl phthalate, derived from methanol (wood alcohol) and phthalic anhydride, an important ingredient of alkyd resins and made from naphthalene, has proved particularly useful in repelling mosquitos and is harmless and almost odorless when rubbed on the skin. Ethylhexanediol, known also as 612, has similar value and a new compound derived from mesityl oxide and butyl oxalate and called Indalone is also valuable for



In this pest-control research laboratory maintained by Du Pont, actual field conditions are closely paralleled. The light from the large lamp simulates sunlight

Courtesy Westinghouse

A soldier demonstrates how the insecticide bomb is used for defense against malaria and yellow fever

similar purposes. In mixtures, these three materials appear to be synergetic and are far more effective than any of them alone or any mixture.

These are outstanding among currently important developments in the field. Older materials, rotenone particularly, are, like these, stringently short and under strict control until war's end

It is too early yet to be sure of the future usefulness of these new methods and weapons against insects, but it is clear that they combine to give new power to our fight against insects. One would be foolish indeed to expect them to replace permanently and completely the customary insecticides. But obviously they will supplement existing materials and techniques to make them all more effective. They will thus be immediately useful to agriculture Their long range value may be confidently expected to lie in opening new areas to safe human habitation and exploitation. Already, backward peoples everywhere are learning that insects and diseases carried by them can be controlled. Soon they will demand help in this respect and will thus be able to raise their own standards of health and of living

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FLUORINE IN TOOTH DECAY

Controlled Experiment to Determine Real Value

TRACES of fluorine in water supplies have been shown to reduce the tendency of teeth to decay, but positive and final proof has been lacking. This is now to be obtained by a gigantic experiment involving the population of two New York State cities and extending over ten years. Undertaken under the eye of the New York State Department of Health, the experiment consists of adding one part per million of sodium fluoride—an amount too small to be detectable by ordinary means—to the water supply of Newburgh, New York The neighboring city of Kingston, having a similar water supply but without natural or added fluoride, will serve as a check. A careful inspection of teeth of school children and others in both cities will be made periodically by dental officials and the results tabulated and compared. The experiment is expected to demonstrate within ten years the value, or lack of it, of fluorine in preventing decay of teeth. It is being undertaken to learn whether this or some other factor is crucial in areas already shown to have low rate of tooth decay and traces of fluorine in water supply.

PENICILLIN PRODUCTION

Has Greatly Reduced Cost of the Drug

PRODUCTION of penicillin has soared to a point where the output in March, 1944, was a hundred times that in the first five months of 1943. Civilians are promised supplies of the new drug sufficient "to treat all urgent civilian cases in the relatively near future." The price of penicillin has dropped from an original figure of $20 per 100,000 Oxford units to $3.25, a reduction of 84 percent in a year In terms of treatment of disease, the present price of penicillin means that the cost of the drug required for a severe case of septicemia is about $35 and for sulfa-resistant gonorrhea, less than $5. In spite of this progress, the actual weight of the drug produced is still small. The completion of the present plant building program is expected to raise the daily output of all plants—costing about $20,000,000—to some nine pounds per day.

COTTON COMPETITION

Can be Met by Introducing Economies

AMERICAN cotton growers have more to fear from the inroads of synthetics than from foreign grown cotton, Ransome Aldrich, president of the Mississippi Farm Bureau Federation, told the National Cotton Council at its 1944 annual meeting. Cheaper production of cotton is necessary to meet the growing threat from rayon, he stated. World rayon production in 1943 reached the equivalent of eight million bales of cotton and is still growing. Economies in cotton farming can take the forms of better, wider, and more efficient use of fertilizers and insecticides, and of mechanization of agricultural operations.

ACTIVATED CARBON

Now Being Produced from Bituminous Coal

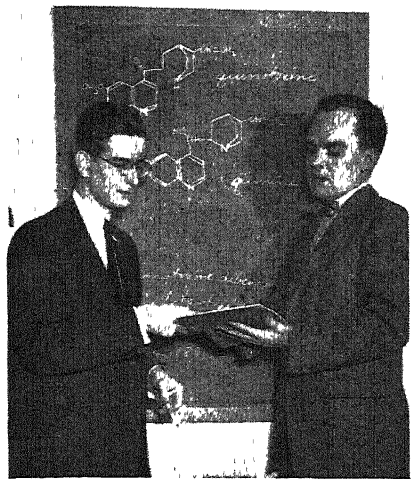
BITUMINOUS coal has been converted by treatment with chlorine into an activated carbon equalling or superior to that formerly made from coconut shells. The operation is still in the early experimental stages but preliminary tests suggest high value for the product. The coal, crushed to pea size, is heated and treated with gaseous chlorine, producing hydrochloric acid and carbon tetrachloride as by-products. The chlorinated coal is pelleted, baked to produce the required hardness, and crushed to the desired size. Subsequent activation is accomplished by treatment with steam at bright red heat. The final product exceeds the specifications of the Chemical Warfare Service, by which such materials are judged, and is expected to have important applications in industry for decolorizing and purifying

QUININE SYNTHESIZED

But May Not Get into Production in War-Time

SUCCESS in one of the longest and most persistent searches of chemists was realized recently with the announcement of the synthesis of quinine by two American chemists, Robert B. Woodward, of Harvard University, and William E. Doering, now of Columbia University, consultants for the Polaroid Company. Details of the synthesis include a long series of successive steps leading to the final product. The discoverers in their announcement state that there is doubt whether their process can be put into production in war-time and they do not estimate costs.

The problem of synthesis of quinine has been unfinished business with chemists for more than a century. One of the early attempts to produce this



Chemists Woodward (left) and Doering, pioneers in synthesis of quinine

important alkaloid led Sir William Perkin to produce the first synthetic dye in 1856 and thus laid the foundation of the modern dye industry. Numbers of chemical compounds studied in the long course of the search have proved highly valuable in fighting malaria, principal use of quinine, and for other purposes. Atabrin and Plasmochin, two trade-marked synthetics, have proved particularly valuable during the dearth of quinine caused by seizure of the Netherlands East Indies by the Japanese in this war. But none of the compounds heretofore produced has exactly duplicated quinine as the present one is said to do.

Highways After the War

Short-Haul Motor-Vehicle Traffic Requirements Will Probably Dominate Post-War Planning in this Field. The Report of the Interregional Highway Committee Shows the Trend Which May Be Expected. Separation of Traffic Flow and Elimination of Grade Crossings are Important Elements

By V. T. BOUGHTON
Associate Editor *Engineering News-Record*

WHAT FORM will our highways take after the war? Will the new ones be similar to those built just previous to the war, or can we expect to see the widespread construction of a network of superhighways similar to those visualized by Norman Bel Geddes in the General Motors' Futurama at the New York World's Fair?

Such questions arise in the minds of many people who attempt to look beyond the war to the day when tire and gas rationing will be but a bad dream and when war bonds can be converted into new automobiles to be used at will. The answer appears to be that the dream highway of the Futurama type will still be dream highways and that post-war highway designs will not depart radically from the types with which we are familiar.

The dream highways of men whose thinking is unhampered by practical considerations have been shown on analysis to be of less real service to the public than the simpler designs of highway engineers experienced in fitting abstract theories to practical limitations. This is not to say, however, that the post-war years will not see many major improvements over existing highways and the construction of many miles of superhighways such as the Henry Hudson Parkway at New York, the Outer Drive at Chicago, the Detroit Expressway, and the Arroyo Seco Parkway at Los Angeles.

There are two main reasons for this conclusion that the early post-war years will bring no radical change in highway design. The first is that our state highway departments will come to the end of the war with a vast accumulation of urgent replacement work that must be done to keep the highways we now have in safe operating condition. These departments are now engaged in making plans for that work and for such new construction as is urgently needed.

The situation with respect to roads is not unlike that with respect to cars to operate on those roads. Replacement of worn-out vehicles will be the major problem of the automobile manufacturers as soon as they can resume normal operations, and the speediest way to replace is to work to existing designs, letting experiments with new models wait.

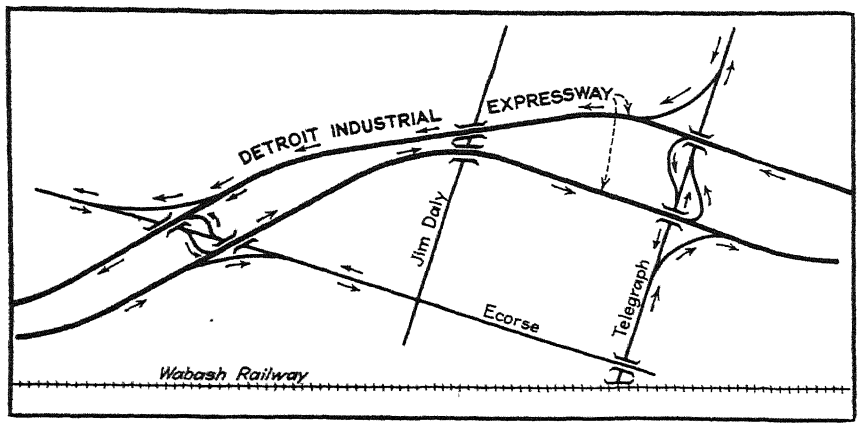
SHORT-HAUL TRAFFIC—The second consideration that will control post-war highway work is even more basic. It finds its origin in the fact that 85 percent of all trips by automobile are for distances less than 20 miles. Long-distance travel that would be served by superhighways running from coast to coast and from the Canadian border to the Gulf states and Mexico, which have been proposed by visionary highway planners for many years, actually would serve only a small percentage of the population. The nation's greatest need, as anyone who drives a car in the densely populated areas will recognize, is for better highways into and through our centers of population.

If the post-war transportation situation is viewed broadly, a clear indication will be found that the percentage of long-distance auto travel after the war may decline rather than increase. Without doubt, air transport will go forward with great strides after the war, and its chief service will be to long-distance travel needs Also, the railroads are becoming acutely aware of the wants of the traveling public Hence, post-war transportation trends may be expected to emphasize the need for better highways to serve the short-haul traffic in and around our cities

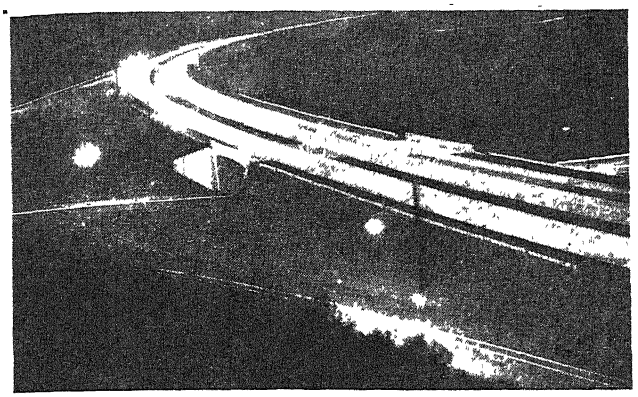
Construction of highways into and through populated regions is a great and costly undertaking that cannot be inaugurated quickly and pushed to early completion. Involved is the purchase of wide rights-of-way through built-up communities, removal of buildings on those rights-of-way, changes in utilities, and the construction of four- and six-lane roads, which generally must be depressed or elevated to eliminate all grade crossings and therefore require an abnormally large amount of bridge construction per mile.

Much study is being given to this type of highway, and those that are to be built will have incorporated in them the latest ideas in highway design. Many will be what are known as limited-access highways, that is, highways which can only be entered or left at certain designated points. In a number of instances, this will result in the construction of parallel roads to serve the adjoining properties cut off from free access to the main road.

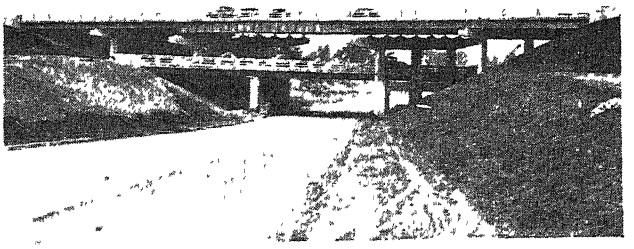
Where these highways are to be built through highly developed regions, an effort will be made to disturb the existing developments as little as possible. Where they lie through run-down areas in large cities, much thought is being given to proposals to make them the starting point for a rejuvenation of those areas. In some cities it has been proposed to take rights-of-way



Instead of the "cloverleaf" intersections built in the period just after World War I, those built following the present war will probably be designed for "directional flow" of traffic similar to the design of the Detroit Industrial Expressway, above



Sodium-vapor lamps were installed to light intersections on the Pennsylvania Turnpike. The post-war era may see some radically new applications of fluorescent lighting



A three-level crossing at the Ford Willow Run plant on the Detroit Industrial Expressway. This highway was designed as the initial part of a future limited-access road

much wider than actually needed for the highway, in order to be able to control the redevelopment of the area.

Also having a significant bearing on what highway work will be undertaken after the war is the fact that the Interregional Highway Committee, set up by the President in 1941, has submitted its report to Congress, proposing that after the war an immediate start be made on the development of a 33,920-mile system of interregional highways as part of the so-called federal-aid highway system This proposed system will not be made up entirely of additions to our present highways, in large part it will be created by the reconstruction or relocation of existing highways Many limited-access roads will be part of that system.

TOLL ROADS FROWNED UPON—Few toll roads, of which the Pennsylvania Turnpike is an outstanding example, will be built after the war. Congressional road policy has long been opposed to toll roads on the basis that state and federal funds used to build highways now come in larger part from gasoline and motor-vehicle taxes, hence the road users already have paid for the highways through such taxes It is of interest to note that the Pennsylvania Turnpike is not included in the Interregional Highway System plan, presumably because it is a toll road.

Motor parkways were built in some parts of the country in pre-war days largely for recreational use, but also to facilitate long-distance travel by private automobiles Some further extension of these highways may be expected after the war, but it probably will be only in regions where special considerations such as a predominance of pleasure driving make that necessary. Roads of this type, such as the Merritt Parkway in Connecticut and the Eastern State Parkway in New York, roughly paralleling the Boston Post Road and the Albany Post Road, respectively, have been a great boon to private automobile drivers wishing to escape the dense commercial traffic on the older roads, yet they have not solved the traffic problems on the older highways. Those roads must still be rebuilt or supplemented by parallel highways open to all types of traffic in order to end the intolerable traffic congestions and accidents in the communities through which they pass at present

This condition serves again to emphasize the fact that it is the short-distance movement of either private or commercial vehicles that make up the great bulk of road traffic.

Probably the best indicator of design trends is the report of the Interregional Highway Committee, which set the basic standard for the highways that are to make up that system.

All rural sections of the system are to be limited-access highways, and on all sections where the average daily traffic exceeds 5000 vehicles, all crossings with other highways or railways are to be separated Where four or more traffic lanes are required, two distinct one-way roads are to be provided rather than a single divided highway.

An example of this type of separated roadways is found in the newer sections of the Eastern State Parkway in New York on which, in hilly country, the opposing traffic routes at times are so far separated as to be out of sight of each other.

Curvature on the inter-regional highway is to be kept as flat as possible, and all but very flat curves are to be superelevated to permit comfortable operation around the curves at high speed. No speed limits are set, but the design speed used in fixing curvature, superelevation, and sight distances range from 50 to 75 miles an hour, depending upon the character of the country—whether flat or mountainous.

Modern practice in the construction of main highways through built-up areas is to depress the roadway below intersecting streets, to restrict access to points where ingress and egress will not interfere with highway traffic, and to provide parallel roads which will serve local needs

At least two 12-foot wide traffic lanes in each direction are to be built on the inter-regional system on all rural roads carrying from 3000 to 15,000 vehicles a day. Not more than three lanes in each direction are to be provided on roads carrying more than 15,000 vehicles a day. Opposing traffic on these latter roads must be separated by median zones not less than 15 feet wide Shoulders, except in mountainous territory, are to be 10 feet wide.

Advertising signs and all structures are to be kept out of a zone 100 feet wide beyond the edge of the pavement by outright purchase of the land or by acquisition of highway development rights. It is proposed that, wherever possible, there be public control along the interregional highway system over a strip of land at least 300 feet wide.

At the separated intersections with other highways, where interchange is permitted, acceleration and deceleration lanes are to be provided outside the regular traffic lanes. Sharp turns requiring sudden reductions in speed on these interchange roads are to be avoided, and the designs are to be such that diverging lanes are to follow as closely as possible the normal direction that a vehicle would follow in moving from the main highway to the intersecting highway.

PROTECTING PEDESTRIANS—Pedestrians are not to be permitted on the pavements or shoulders. In rural areas, where necessary, pedestrian paths and overpasses are to be provided. In urban sections, sidewalks will be provided along the parallel service streets

It is too early to predict what highway lighting developments after the war will be, because the strides made in the development of fluorescent lighting for war plants seems to indicate that there will be much wider use of that type of lighting after the war. Such a development is bound to have

its effect on highway lighting. Indicative of this is the design of a bridge being made for the California Highway Department in which the sidewalks and roadways are to be lighted by fluorescent tubes underneath the handrails and so placed as to light the roadway and walks without being visible to automobile drivers. This development is more fully described and illustrated elsewhere on this page

All in all, such factors in highway construction as will contribute to public safety and convenience will appear largely in post-war planning, with emphasis on practical rather than spectacular aspects

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BARGES

Have Welded Steel Frames

Encased in Concrete

A NEW type of barge consisting of a welded steel frame of lightweight H-sections tied together with reinforcing bars and encased in concrete has been built in England. The barges are of two sizes, 200 and 400 tons dead weight, the smaller size having a length of 85 feet, a deck width of 22 feet, and a draft of 8½ feet. British patent rights have been granted for this type of ship construction, and American and other rights are pending.

The steel frames are of 6 inch, 12 pound sections, and are spaced on 1.25 foot centers. Concrete panels are cast between the steel frames, the concrete surfaces being flush with the surface of the steel section flanges

BRIDGE LIGHTING

Accomplished from

Concealed Sources

EXPERIMENTS are being conducted by the California Division of Highways that promise to provide a novel method for lighting the sidewalks and roadways of bridges. The plan involves the installation of a continuous line of reflectors on the hand rails, from which concealed sources of light will emanate their rays. Thus the lights will not shine into the eyes of motor drivers but will give maximum illumination on the sidewalks and at the edges of the roadway.

Final decisions have not yet been made but it is expected that the most economical source of light will be luminous tubes mounted horizontally in a position of maximum security and protection beneath the hand rails

HIGHWAY PROGRAM

Would be Carried Out as

Post-War Project

CREATION of an interregional highway system of 33,920 miles has been proposed to the Congress by President Roosevelt who has approved a report made by the National Interregional Highway Committee The committee, which was appointed by the President in 1941, stated that work on the system should be undertaken as a post-war project and carried forward at the rate of about $750,000,000 a year for several years.

The proposed work would include modernization of some existing routes and construction of new highways that would connect directly all cities of 300,000 or greater population [See also feature article, page 16 — *Editor*]

CONCRETE STRENGTH

Retained Despite

Long-Time Mixing

SAMPLES taken at 30-minute intervals from a batch of concrete that was mixed over a four-hour period indicated that there is little loss of strength through long-time mixing, as measured by standard test cylinders broken after a 28-day period of setting

The test was made by the Department of Public Works of New York City, and was intended as a guide to the effect on slump and strength of abnormally long-time mixing in truck-mounted mixers.

WASTE CONTENT

Determines Charge for

Use of Sewer

INDUSTRIES that discharge their wastes into the municipal sewer system in New Brunswick, New Jersey, must now pay a special charge for this service, the rates being based on the volume of flow, solids content, and the chlorine demand of the waste.

This three-part rate schedule is intended to provide a fair measure of the "load" placed on the municipal sewage treatment plant by individual industries. According to Chester W. Paulus, mayor of the city, New Brunswick was forced to take this action because excessive waste discharges from war industries had greatly increased operating costs at the city's disposal plant.

The ordinance setting forth the established industrial waste rates provides charges based on $22 per million gallons of flow, $5 per ton of solids in the wastes, and $5 per one hundred pounds of chlorine demand exerted by the waste liquid

ARMY BRIDGE BUILDERS

Use Special Trucks for

High-Speed Operations

A COMBINATION equipment carrier and erection unit is being used by the United States Army combat engineers to expedite temporary bridge installations. In a recent test a 330-foot pontoon crossing was completed in three hours and two minutes

The unit consists of a heavy army truck on which is mounted a special steel carrier body and an 8000-pound capacity crane Each unit carries pontons, steel saddles, and four 2000-pound treadways for 30 feet of bridge The trucks are 31 feet long and weigh 26 tons loaded

One of the features of the unit is the 14-foot crane at the back of the truck. This is hinged at its base, and is hydraulically controlled Swinging from its traveling position along the outside of the body, it is designed to pick up the heavy steel treadways, two at a time, and unload and position them for subsequent attachment to the pontons.

WATER SUPPLIES

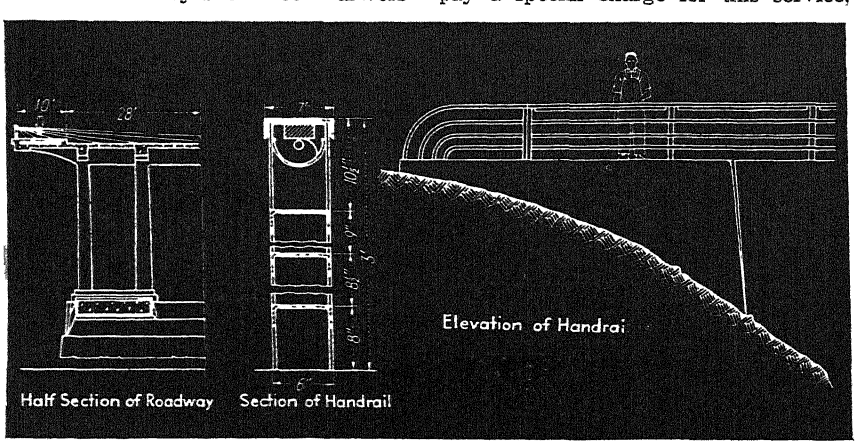
Will Be Widely Extended

After the War

ADDITIONAL water-supply facilities that are needed in the United States will cost more than $683,000,000, according to an inventory compiled by the United States Public Health Service. Extensions in 6455 communities will cost an estimated $502,000,000, and new systems in 4863 places will require an expenditure of $181,000,000

Although more than 99 percent of the communities in the largest population groups (5000 and over) are served by public water-supply facilities, only 43 percent of the towns with less than 1000 population are so provided.

Public water supplies date historically from the year 1652 when the first system of its kind was instituted at Boston. In 1900 there were about 3200 systems, and in 1940 the number approximated 14,500. At the present time about 84,500,000 people are served by public water supplies.



How fluorescent lamps provide concealed lighting for bridges

Continuous Casting

A Number of Relatively Simple and Inexpensive Machines Have Been Perfected in which Molten Metal is Poured into One End and Continuous Lengths of Billets, Sheet, or Strip Emerge from the Other End. Practically All Aluminum, Magnesium, and Copper Alloys are Now Cast in this Manner, and Experiments Currently Under Way with Steel Show Great Promise

By T W LIPPERT
Editor *The Iron Age*

FOR CENTURIES metal has been poured into molds to solidify into ingots These ingots are subsequently heated to a plastic temperature, and rolled through many stands of rolls into sheet or strip; or rolled into tubing, bars, and structural shapes; or rolled into bars which later are drawn into wire or forged into a variety of machine or equipment parts.

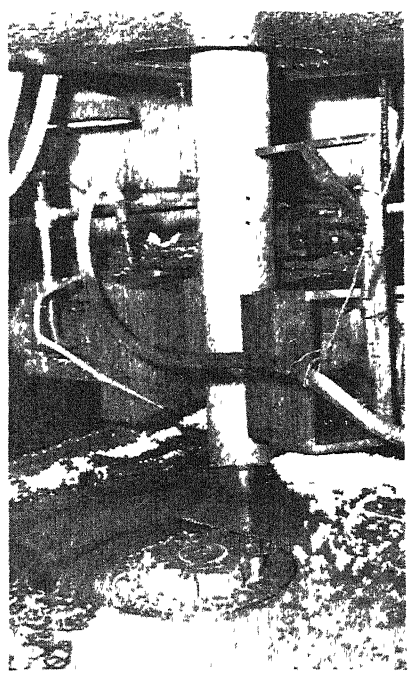
Today, one single ingot of steel may weigh 5, 10, 20, or 30 tons This large mass of metal must later be heated to plastic temperature and gradually worked down until the final finished product becomes a thin sheet or strip, or even a wire hardly thicker than a human hair. This working-down process involves a great many operations, equipment valued in the many millions of dollars, high metal scrap losses, and infinite care to assure comparable physical properties from ingot to ingot.

It has long been a dream that perhaps this large ingot could be avoided, that perhaps all these expensive and time-consuming working operations could be minimized To this end, a number of machines have been perfected, whereby molten metal is poured into a simple and compact mold and the heat extracted by high-velocity water sprays. The products emerging from this mold are continuous, uniform as to physical and surface conditions, and of such a size that only a relatively few additional rolling operations are necessary to get the metal into final form of strip, sheet, bar, or structural shape.

These machines, being compact and relatively inexpensive, greatly reduce the equipment necessary to fabricate metals. Furthermore, scrap losses are very small, and quality of metal frequently is superior to that turned out in the conventional manner.

Two general classifications of continuous casting machines are in operation. The most common type turns out solidified metal in the form of round, square, or rectangular billets. This metal goes to rolling or extrusion machines for reduction into a finished form. Another, less successful, type converts liquid metal directly into strip or sheet that requires only a few simple additional cold-rolling operations to produce a finished metal.

Based solely on the criterion of tonnage of commercial metal produced, the Alcoa DC (direct casting) equipment is by far the most successful in operation in this country. Every ounce of aluminum and magnesium extrusion rounds and sheet ingots produced by the Aluminum Company of America, with the exception of the simple 2S and 3S analyses, passes through this type of continuous casting unit.



A 14-inch round billet of aluminum alloy being continuously cast at a speed of 12 to 15 inches per minute in a Rossi machine at an Extruded Metals Corporation plant. The solidified metal comes from the mold chamber and is cut into two-foot lengths by the horizontal saw, which moves with the billet while cutting

TRANSITION IN CASTING—Large tonnages of aluminum and magnesium similarly are handled in Alcoa-licensed machines in the plants of Extruded Metals, Revere, Bohn, and Tube-Turns Thus it is apparent that the bulk of the country's light metals has passed from conventional casting equipment into continuous casting machines during the past several years.

For example, a DC unit at an Alcoa plant is now producing at a rate of about 25,000 pounds of metal every eight-hour turnout, but this output can vary considerably, depending on ingot size, number of molds being poured simultaneously, and analysis of metal being poured.

In the case of this particular machine, the melt has a furnace temperature of 1375 to 1385 degrees, Fahrenheit, and passes down a runner to a cast-iron distributor pan, equipped with four cast-iron nozzles, individually controllable, each of which feeds a casting chamber. Metal temperature in the pan is, say, 1270 to 1325 degrees, Fahrenheit, and a metal head of about 5 inches is maintained in the pan.

The molds are simple aluminum tube sections 10 inches in length, set into a steel plate framework. About one quarter of the heat of fusion is extracted through the mold wall, which is cooled by water sprays or jets. The remaining heat is extracted by multiple water sprays directed around the periphery of the ingot shell.

A hydraulic platform underneath the molds drop down at a speed of about 3 inches per minute, carrying the four casts with it. The entire cast (or drop) takes about 40 or 50 minutes, at which time the ingots are some 10 feet or more in length, depending upon the size of the heat. At the end of the cast, the distributor pan is removed, the platform is lifted sufficiently to loop crane slings around the ingots and lift them from the pit. Subsequently the platform is again lifted to floor level, the distributor pan again set in place, and everything readied for another cast. Of course, if so desired, the platform arrangement could be replaced by pinch rolls and automatic cut-off saws.

Well over 60 DC units are in continuous commercial operation in this country. The mold sizes vary from 8 inches to 16 inches in diameter for round

extrusion ingots, sheet ingots vary in cross-section from 6 by 22 inches to 12 by 48 inches; and sizes for blooming-mill work vary from 8 by 8 inches to 18 by 20 inches in cross-section. Some of the older units cast in 90-inch lengths, whereas the newer units cast in lengths in the neighborhood of 140 inches.

These sizes apply for both aluminum and magnesium, although magnesium sheet ingot cross-sections are usually of the smaller size mentioned above. In magnesium, emphasis on round castings for extrusion is expanding considerably with the growing tendency to pre-extrude all strip billets, a practice for years common with I G Farbenindustrie in Germany.

FOR DAYS AT A TIME—The Junghans (Rossi) method of continuous casting makes use of an orthodox unit in which casting of large billets may continue uninterrupted for days at a time, the metal being cut into billet lengths by means of a flying saw while in motion. In 1940 only one American company, the Scovill Manufacturing Company, had a Junghans machine in operation, and it had already cast some 60,000,000 pounds of commercial brass, mostly in 7⅞-inch round sizes. This cumulative figure is currently approaching 400,000,000 pounds.

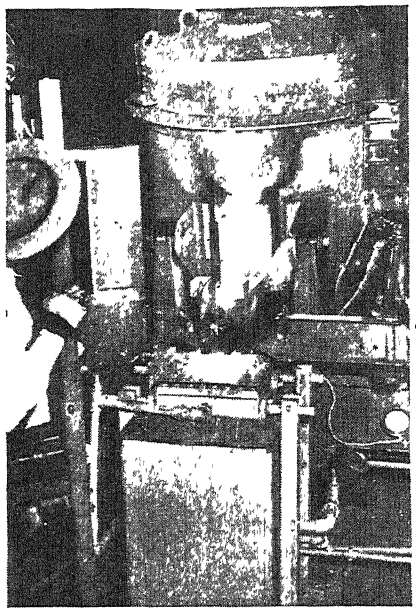
In April, 1940, James Booth, Ltd., Birmingham, England, had just initiated production in a larger Junghans machine, casting aluminum alloys, mostly extrusion rounds up to 16 inches in diameter. A few Junghans units are also in regular use in Germany on aluminum alloys and brass. Although most of the German plants have been bombed repeatedly over the past six months, some information coming out of the country via Switzerland since the war leads to the belief that there has been great expansion in Junghans installations all over Germany, designed primarily to supply light-metal extrusion rounds for the aircraft industry, and cartridge brass rolling ingots for the ordnance plants.

Since 1940, a number of larger and better engineered Junghans-Rossi machines have been built in the United States, for use primarily in the brass industry. In addition to the original Scovill unit working on extrusion rounds up to a maximum of 10 inches in diameter, the same company has since 1940 installed a larger machine primarily for brass sheet slabs up to a maxium width of 24 inches.

A neighboring company, the Bridgeport Brass Company, has installed three Junghans-Rossi machines, one for slabs up to 30 inches wide, and two for extrusion rounds up to 10 inches in diameter. The Extruded Metals Corporation over a year ago initiated production in a unit for aluminum rounds up to 14 inches in diameter.

An accompanying photograph of the Extruded Metals Corporation unit illustrates the use of the Junghans-Rossi machine on aluminum alloy extrusion rounds. Delivery speed of this machine is anywhere from 5 to 20 inches per minute, equivalent to some 100,000 or so pounds of aluminum alloy billets per eight-hour turn.

As new Junghans-Rossi machines are developed, the casting speed is slowly rising. Scovill is now casting eight-inch diameter brass billets at the rate of 16,000 pounds per hour, or about 360,000 pounds per day, and this rate is maintained for days on end. At the Bridgeport Brass plant this hourly rate



Continuously casting a six-inch square billet of steel in a Williams machine. The molten steel pours from the electric furnace and is cooled in the mold in the foreground by means of high-velocity water flow. The billet comes from the mold at about 10 feet per minute and is cut to length by an oxygen lance

has been greatly increased though not for such extended periods. The rates for aluminum run about 40 percent higher. Each machine normally requires three men for operating it.

The conspicuous and unique characteristic of the Junghans machine is that the entire mold, water jacket and all, moves down at the same speed as the emerging billet for a distance of several inches, and then snaps back to its original position, the snap-back speed being about three times the speed of the billet. The function of this movement is to present a constantly changing section of the mold wall to the molten metal, which in turn facilitates freezing a skin onto the molten metal. The infrequent relative movement between mold and metal also tends to minimize skin ruptures.

After the cast ingot leaves the mold (or, rather, the mold moves upward away from the cast metal), the metal obviously requires considerable additional cooling. This takes place in a circulating body of water, fully enclosed and at the bottom of which is a rubber squeegee seal, which prevents water from running down the ingot and messing up things below the casting floor. The ingot, as it emerges from the squeegee, is both cool and dry.

At the American Smelting and Refining Company plant, an experimental-commercial continuous casting machine has been in operation for some four years, turning out large tonnages of oxygen-free (phosphorized) copper billets up to three inches in diameter, which are sawed into 50-foot lengths for use primarily in the production of seamless tubing. The surface condition of this metal is smooth and free from flaws, the metal is dense and uniform, and in general it is a high-quality product superior to that produced in prior conventional equipment.

This machine is essentially a refractory (graphite) chamber holding a sizable quantity of molten metal, with automatic temperature recording auxiliaries for holding the metal within close limits and with facilities to protect the metal against oxidation In the bottom of this chamber are set four graphite dies along with their individual cooling arrangements The continuously cast rods are individually withdrawn from these dies and either reeled or cut into lengths by saws

The machine works continuously, day and night. If, after several hundred hours of service, a particular graphite die should wear it can be removed and a new one replaced without interrupting the casting in the other dies. The multiple die arrangement overcomes the disadvantage of the very slow production of a small cross-sectional cast of metal from each die, and the unit as a whole has a most respectable hourly output—on the order of several thousand tons monthly

PROCESSES FOR STEEL—All the machines so far described have dealt with continuous casting of non-ferrous metals in ingot or billet form. Whereas the Junghans-Rossi machine has been used in Germany for casting steel, surprisingly enough no effort so far has been made to give it a trial for steel in this country.

In the continuous casting of steel ingots or billets in the United States, by far the bulk of experimental work has been carried out by the Williams Engineering Company, under the direction of Edward R. Williams, president of Vulcan Mold and Iron Company. The Williams patents are concerned principally with mold design and methods of mold cooling and lubrication.

Williams makes his mold of commercially drawn copper or brass tubing of about ¼-inch wall section, which mold is fastened into an accurately machined cooling chamber. The wall of the heavy steel cooling chamber is separated from the inner mold wall by only a fraction of an inch, and a multitude of flutings in the cooling chamber press against the mold wall, keeping it in shape and directing a high-pressure water flow along the mold wall to scour the heat away rapidly.

The Williams mold does not move. As the billet or ingot emerges from the bottom it passes through a series of sizing rolls that prevent bulging of the walls by ferrostatic pressure from the molten chamber. Water sprays surround these sizing rolls and the

ingot is almost cool when it gets down to a set of pinch rolls which withdraws the ingot from the mold. Mold lubrication is frequently used, and this is automatically introduced around the edge of the molten metal pool by a multitude of orifices, the volume of lubrication being controlled by the speed of the pinch rolls withdrawing the billet

About a year ago, the Williams process was taken over by the Republic Steel Corporation for extensive experimental investigation at the Cleveland Corrigan-McKinney plant.

It is believed that present mold design limits the casting of, say, a 3 by 8½-inch section to speeds of from 5 to 8 feet per minute Since faster speeds are desirable, some alteration in mold design may have to be evolved Republic is currently constructing new molds incorporating many refinements.

The only other equipment in experimental operation with steel is that designed by Norman P. Goss, of the Cold Metal Process Company. A machine has been built and operated at intervals at a plant of the American Steel and Wire Company. Goss provides for a mold made up of numerous sections, each section individually cooled

Particularly interesting is the means provided whereby, as the metal skin freezes and pulls away from the mold wall, a finely divided solid material is introduced through many orifices in the mold wall. This material is capable of remaining solid during the casting operation and also capable of accommodating itself to the interstices between the cast metal and die wall In this manner the walls of the die are protected from abrasion and galling, and the congealing metal is also protected from run-outs and abrasion. This material also maintains a heat-conducting contact between the ingot skin and the die wall. Like the Williams process, the Goss method of casting steel needs considerably more experimental investigation, but can well be a method very much worth watching for the effect it could possibly have on the economics of steel production

FROM LIQUID TO STRIP—All the previous methods of continuous casting have turned out ingots or billets that are subsequently extruded into structural sections or rolled into strip. The C. W. Hazelett process, however, converts liquid metal directly into sheet or strip, by pouring the molten metal between two water-cooled revolving rolls. Several units are installed and in varying stages of activity or experimentation.

Results to date have been encouraging. A great deal of excellent brass has been rolled on one unit for the Army, in six-ton heats, the continuous strip being up to 30 inches wide and 0.012 inch thick. The mill is now working on copper, and probably will handle large copper strip requirements after the war.

In addition to the interest that one United States Steel Corporation subsidiary has in the Goss process, the Corporation also has patented a somewhat unusual continuous casting machine, and intends to give it an experimental whirl. The significant feature of the machine is the casting (or extrusion) of a ceramic mold around the liquid metal as it is cast into a billet.

Dow Chemical Company and Reynolds Metals Company have developed machines similar in some respects to the Alcoa equipment previously described.

A bar and billet casting machine has been devised by the International Nickel Company of Canada and is in use at one American Metals Company plant. Inco of Canada has one unit in operation on copper at Copper Cliff, Canada. The American Metals machine continuously casts three-inch square copper wire bars or three-inch piercing billets at a rate of about 4000 pounds per hour. The copper is continuously fed from one of two melting furnaces, through a closed runner to the mold chamber. The mold is copper, with many internal passages for coolant.

Particularly interesting is the fact that the mold is split in two parts axially, and these parts vibrate very rapidly to overcome friction, the amplitude of the vibration being very small, or less than enough t break the surface tension of the m en metal pool on top. Metallurgical cl. racteristics of the metal are excellent and surface condition of the bar is so good as to not require scalping prior to subsequent manufacturing operations. This machine is very successful in all respects, and additional installations are to be expected.

The outstanding features of this overall development of continuous casting are the tremendously accelerated rate of installation and technical progress in the last ten years and the positive interest now being shown in the process by some of our largest metal-producing companies.

SMALL DIE CASTINGS

Made Rapidly by New Process

EXTRAORDINARY possibilities for postwar designers have been opened by the recent development of a process for die casting tiny parts at remarkably high rates. Costs are so low that the die-cast products may successfully compete with virtually identical items heretofore made on cold headers, wire-forming machines, screw machines, punch presses, and so on

The die casting machines used not only operate automatically but are equipped with supplementary attachments that remove the casting from the die, cut off the gate, trim the flash, and so on. Despite their small size, many of the castings are precisely cored.

The process, developed by Crown Fastener Corporation in conjunction with Gries Reproducer Corporation, is in use for the production of zinc-alloy slide fastener elements die cast directly onto the tape, for separately die-cast fastener slides, stops, and locking parts, and for other small zinc alloy castings such as brads, rivets, various types of pins, rings, buttons, and so on. The machines operate at the rate of several hundred shots per minute.

Die castings as small as ⅛ inch long and ⅛ inch in diameter have been made by this process. In general, it has demonstrated its utility for parts weighing less than ½ ounce and not over ¾ inch in maximum dimensions Tolerances can be held from minus 0.000 to plus 0 003 inch across a parting or down to ±0.001 inch within integral portions of the die

STELLITE REFLECTORS

Stand Up Under Naval Service Conditions

PARABOLIC reflectors for Navy use in sizes up to 36 inches n diameter must meet rigid requirements—high reflectivity; permanent resistance to tarnishing by salt air, spray, powder fumes, resistance to shattering; resistance to pitting from hot particles of the searchlight electrodes and to oxidation from the heat of the nearby arc

Trials with silver- or chromium-plated steels and other reflector materials were unsatisfactory. The Navy finally decided upon the heat- and corrosion-resisting Stellite alloys (nominal composition 55 percent cobalt minimum, 33 chromium maximum, and 6 tungsten maximum), which were found to be free from corrosion, pitting, and dulling, and to withstand several months of outdoor exposure without loss of reflectivity

The Stellite alloys, long used for cutting tools, are generally considered difficult or impossible to form in sheet metal and to machine. Actually these reflectors are far and away the largest parts requiring forming, machining, and polishing in which these alloys have ever been made

While the reflectivity of Stellite is only about 68 to 70 percent, it has the great advantage of maintaining that reflectivity under service conditions Silver's reflectivity of 95 percent is much higher but it tarnishes and scratches more readily. The whole development is a step forward in the working of hard materials that will be adaptable to peacetime production.

NATURAL-AGING ALLOY

Requires No Heat-Treating to Develop its Properties

DEVELOPMENT of a sand-cast aluminum-base alloy containing 0.5 percent magnesium, 5.25 percent zinc, and small amounts of titanium and chromium, that provides high physical properties without a prior solution or quenching heat treatment was described by Hiram Brown, metallurgist of Frontier Bronze Corporation at the recent annual meeting of the American Foundrymen's Association

Known generally as A.F.A. alloy, B-81, the alloy meets Army-Navy-Air

(*Please turn to page* 42)

Man Against Oxygen

In the Perpetual Struggle to Prevent Oxygen from Combining with Man's Best Metals, Such as Iron, the Petroleum Corrosion Preventives, Now Proved Up in the War, are Shouldering their Way into Wider Use—Just as They Shoulder their Way Under the Water that Causes Rust

By R. G SLOANE
Technologist, Standard Oil Company (New Jersey)

PEACETIME toll of corrosion in industry runs into many millions of dollars Some of the corrosion comes from contact with corrosive chemicals in process industries, some from contact with water or steam as in the boilers in power plants, and some simply from exposure to the air which, in industrial areas, is particularly corrosive because of its content of sulfur-containing gases Protection against corrosion from exposure to the atmosphere or from immersion in water may be obtained by coating metal surfaces with a film of specially prepared petroleum products

A number of theories have been advanced in explanation of corrosion In the case of iron exposed to moisture, the corrosion manifests itself by the formation of rust. When iron is immersed in water, iron ions, or electrically charged iron particles, travel into the water. The iron ions are positively charged and combine with negatively charged hydroxyl ions to form iron hydroxide. Oxygen dissolved in the water oxidizes the products, resulting in the formation of a mixture of iron oxide and hydroxide recognized as rust.

IMPURITIES HASTEN BUST—The rusting, or corrosion, of iron is accelerated by heterogeneity in the iron; that is, by the presence of small amounts of other metals. When iron containing small amounts of other metals is immersed in water, electric currents are set up between the different metals, and the resulting electrochemical action carries the electrically charged iron particles into the water. Samples of extremely pure iron have been found that have survived many years with little corrosion.

The corrosion-resistant properties of some metals result from the formation of protective films on their surfaces when they are exposed to moisture or to a corrosive atmosphere. For example, on tin and aluminum extremely durable transparent films are formed which do not greatly impair the luster of the metal. In the same way nickel and chromium surfaces are protected by unnoticeable impervious films. Copper on exposure to the air develops a protective coating of the green carbonate of copper often seen on old roofs.

Iron and steel may be protected from corrosion where structural limitations permit by plating with a resistant metal. For example, corrosion-resistant galvanized iron, made by dipping iron into molten zinc, is familiar to all, and so is tin-plated iron made by dipping iron into molten tin in the form of the tin can. Less extensively used, but finding considerable application for decorative and special purposes, are nickel and chromium plating as means of avoiding tarnishing or corrosion

The extent to which alloys and plating may be employed as expedients for protection against corrosion is limited by the use to be made of the finished metal. A razor blade, for example, must be made of a material adapted to yielding a sharp edge that will not dull rapidly in use. For this purpose there is no alternative to the use of steel. Neither alloying nor plating are possible.

Ball bearings must also be made of steel to withstand the loads to which they are subjected in service. The ball bearings for delicate instruments are precision machined and polished to a mirror-like finish, and must be carefully protected from corrosion throughout all handling operations. However, the use to which ball bearings are put makes it impossible to resort to alloys or plating to circumvent corrosion. Some alloys would be costly, some would be difficult to manufacture into bearings, and many would lack the needed mechanical strength Metal plating would be difficult to machine and polish, and might peel off in service. For many purposes, iron and steel must be used in spite of their susceptibility to corrosion. Thus cast iron and steel are used for automobile and aviation engine parts such as the block, crankshafts, and connecting rods. Where conditions permit, however, as in the case of carburetors, corrosion-resistant alloys are used.

Because of its inherent elasticity or strength, steel is used in springs, wire ropes, and other objects subject to continuous flexing in normal service. Here plating, even where it does not impair the characteristic properties of such objects, still has objectionable features as a means of protecting from corrosion—for example, it is likely to be cracked and destroyed by the flexing. For objects of this sort an adherent protective coating that offers no resistance to the motion of the steel is needed.

Petroleum products offer ideal means of making adherent, flexible protective coatings. Everyone knows that an object dipped in a petroleum product such as lubricating oil becomes covered with an oily film that is difficult to remove The object may be wiped with a cloth but the final trace of oil remains firmly attached to the surface The object may be placed in a container of water or held under a stream of water and still the oil refuses to leave the surface Moreover, there are many types of petroleum products, some of which give more tenacious films than others. Kerosene will give an object an oily feel, but the oil film may be removed without too much effort A lubricating oil is much more difficult to remove Heavy, tarry residual oils of a semi-solid nature must be heated to be removed from a metal surface

TWO IMPORTANT FACTORS—Two factors that enter into the ability of an oil coating to resist removal by external influences are fluidity and adhesiveness

A fluid product will eventually flow off a metal to which it has been applied. The more fluid it is the more quickly it will flow off, leaving behind the exposed metal. A less fluid, or viscous, material will flow off much more slowly. A solid, such as paraffin wax, applied to a metal surface, will not tend to flow off, but may crack and chip off. To be satisfactory, a protective coating should have the permanence of a solid, combined with the flexibility of a fluid Coatings that approach this characteristic can be prepared from petroleum by combining solid and liquid products into semi-solid materials.

Adhesiveness, the second of the two factors just mentioned, is important if the protective coating is to withstand severe external influences. Some oil coatings might resist removal in a

moderate stream of water but not withstand the effect of sun, wind, and rain when applied to outdoor equipment. Coatings that are to be used for protecting military and industrial equipment under severe exposure conditions for prolonged periods of time must possess a high degree of adhesiveness.

Objects requiring corrosion-protective coatings vary from parts for precision instruments, on which the corrosion from a finger-print is objectionable, to heavy machinery and pipes in storage exposed to severe atmospheric conditions. No single kind of coating would adequately serve all purposes A large series of different coatings is required, and such a series may be made from the many fractions derived from petroleum.

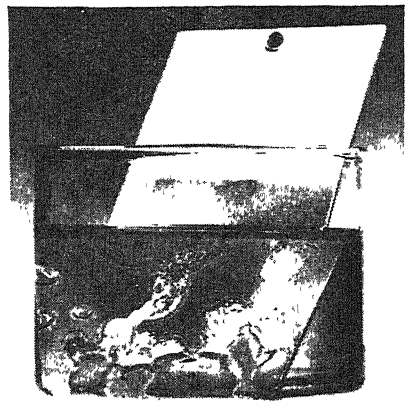
Petroleum protective coatings may be classified according to their consistency into fluid and semi-fluid, or "hard," coatings.

Fluid petroleum coatings with widest range of application are the so-called non-drying coatings They impart excellent protection, good durability, and freedom from hardening, cracking, or peeling. Yet they may readily be removed by wiping off with a petroleum solvent. These protective coatings are generally applied as temporary corrosion preventives with the intention of removing them at some subsequent time and, being of non-drying type, they can easily be removed when desired.

Some of the Rust-Bans[1] of the Standard Oil Company (New Jersey) are examples of non-drying petroleum coatings. They have the advantage over simple petroleum coatings that they contain rust inhibitors to offset the electrochemical conditions that cause rusting; and some of them also contain ingredients with high affinity for metal surfaces, that enable the coating to displace water when applied to wet metallic surfaces.

A good fluid-type protective coating on a metal should tend to spread over the surface and adhere to it tenaciously. The power to spread is related to surface tension. The surface of a liquid behaves like a stretched sheet of rubber. That is, it appears to have a definite tension This results from the fact that there are no molecules of the liquid beyond the surface to counteract the molecular attraction from within the liquid. The unbalanced attraction gives the surface a film-like property which, like the skin of a balloon, holds liquid drops together. The same property makes it possible to "float" a needle on the surface of water, and makes it possible for insects to travel over the surface of a pond or lake. For good spreading power a fluid should have low surface tension, so that when the fluid is brought in contact with a surface it will not tend to retain the form of discrete droplets but will collapse into a film, spreading over the surface. Water does not readily spread over a metal because it has high surface tension but when soap is added to the water, thereby lowering the surface tension, the soapy water spreads easily over the metal Since the surface tension of petroleum oils is low they tend to spread, forming a film over metal surfaces to which they are applied.

After good spreading power, a second requirement of a fluid protective coating is that it adhere firmly to metal surfaces. The ability to adhere may be attained by incorporating in the coating a substance having chemical affinity for both the petroleum coating and the metal surface. A number of substances like fatty acids consist of long chains

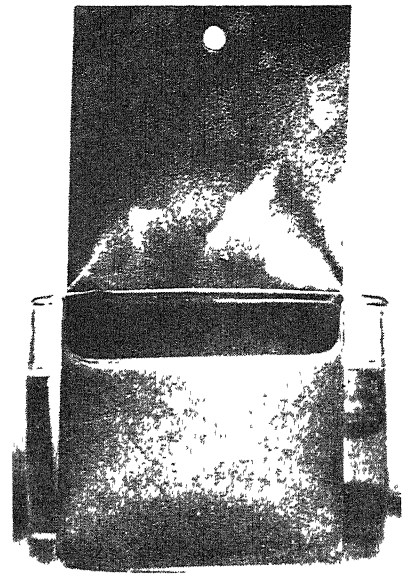


If a piece of metal is wetted with water and dipped in ordinary petroleum oil, the water remains and the metal rusts. Obviously, therefore, a Rust-Ban is more than simple oil

of carbon and hydrogen atoms, one end of the chain having oxygen or other atoms. The carbon-hydrogen chain is chemically quite unreactive, while the oxygen-containing end is reactive and has an affinity for metals. Such substances, if present in a protective coating on a metal surface, become oriented, the active end of the molecule becoming chemically attached to the metal, while the carbon-hydrogen portion of the molecule dissolved in the petroleum holds the petroleum to the metal surface. (A similar explanation has been advanced for oiliness in lubrication. Superior oiliness, which depends upon resistance to rupture of the lubricant film, is effected by fatty acids in lubricants because the oxygen end of the fatty acid molecule attaches itself to the bearing surface, while the body of the fatty acid molecule extends into the lubricant—like blades of grass in a stream of water)

Molecules of the type of fatty acids are called polar compounds. As with magnetic needles, one end is attracted by its chemical affinity to metal surfaces. When a coating of a corrosion preventive containing polar compounds is applied to a metal surface, the affinity of polar compounds for metals causes them to migrate through the petroleum vehicle to the metal surface.

To insure that the attachment will resist rupture when in contact with water, Rust-Bans contain polar compounds that have a partial affinity for water as well as for the petroleum and the metal surface. Consequently



Here the only difference is that the petroleum oil now contains Rust-Ban, which has crept under the water and shouldered it off, also coating metal

any water droplets that find their way into a protective coating are surrounded by the polar compounds, forming a water-in-oil dispersion which prevents further movement of the water through the protective film. The dispersion is semi-rigid in nature, forming an effective barrier to the passage of water and affording protection from corrosion for a long time.

As a rule protective coatings are applied to clean, dry, metal surfaces immediately after they have been finished or polished When a surface has been in contact with water, it is generally dried before the application of a protective coating. However, a special coating, Rust-Ban 392, is applicable to wet surfaces, as it possesses the ability to displace the water and replace it with a film of rust preventive

An illustration of the application of petroleum products having water-displacing properties was their use for the protection of fittings and machinery on the Navy transport, the *Lafayette*, formerly the French luxury liner *Normandie*, after the ship had burned and turned over at its berth in the Hudson River, New York.[2] Without such protective coating a heavy loss to the machinery would have inevitably occurred. A series of protective products were used in the salvage operations

LITTLE RUST IN THE DEPTHS—Little rusting ordinarily occurs on metals which are deeply submerged, as was most of the equipment on the *Normandie* As has been indicated, oxygen plays a part in rusting, and the content of oxygen dissolved in water decreases rapidly with depth. However, as soon as submerged metal is brought to the surface it is attacked by oxygen and rusting occurs at an almost visible rate.

Much of the *Normandie's* equipment was of such a nature that it could not readily be dried. Encased or com-

[1] The Rust-Ban trademark is registered in the United States and elsewhere by the Humble Oil and Refining Company.

[2] Scientific American, November 1943, page 293

plicated machinery, for example, could not be disassembled promptly enough to be protected from rust in that way. It was for this reason, and to assure more certain protection, that equipment was dipped, swabbed, or sprayed with the rust preventives Even electric motors were so treated, although ordinary oils are injurious to motor armatures

The ship's gyroscope compass, a delicate and complex piece of equipment, was so successfully protected that replacement of only two parts and a motor was required The gyroscope was then ready to be installed in the vessel after being taken from its long soaking in the depths of the river.

In addition to main turbines, motors, and gyroscopic control devices, the equipment treated with rust preventive included hundreds of tons of pumps, lamps and lighting fixtures, kitchen utensils, laundry equipment, ice machines, and a great variety of other mechanisms. By preventing destruction of these materials from corrosion, a great quantity of critical material and innumerable man hours of manufacture were saved, and the return of the *Normandie* to service has been greatly hastened.

TOUGH TESTS—Petroleum rust preventives are subjected to a number of tests designed to simulate conditions under which they will be used It is considered more reliable to test finished materials in this way than to attempt to measure fundamental properties. A large number of tests have been devised, the more important being the humidifier test, the water spray test, and the salt spray test.

In the humidifier test, metal panels with uniformly prepared surfaces are coated with rust preventive and placed in a special cabinet through which air passes at the rate of 12 cubic feet per hour. This air is maintained at 100 percent humidity, heated to 100 degrees, Fahrenheit, and directed into the cabinet against baffle plates which insure uniform air distribution. The rate of flow of air through this cabinet is critical in determining the breakdown period of a coating. Under static air conditions certain coatings may last months in this cabinet. With air circulating, the time of breakdown is accelerated to a matter of hours.

Coatings comparable in purpose and consistency are placed on special test panels and the measure of quality is the number of hours that elapse before initial corrosion takes place, as determined by visual examination.

In the water spray test, panels are placed at a 30-degree angle from the horizontal and subjected to a two-foot fall of tap water. This water is maintained at 75 to 80 degrees, Fahrenheit, and allowed to "rain" on the panels for three minutes, then is turned off for three minutes. The cycle is repeated until the coatings fail and the first visible signs of corrosion appear. This test evaluates the strength and resilience of the protective film against the impingement of water.

Strangely, some products which protect nicely from heavy weathering (as rated on the water spray test) are not outstanding in humid atmospheres. This is because at the higher humidifier test temperatures some protective coatings are destroyed relatively faster than at the lower water spray temperatures. For full outdoor exposure the best protection will come from a product that rates good in both the humidifier and the water spray test

For the salt spray test, another specially constructed cabinet is used Panels are hung vertically and subjected to a spray consisting of a 4 percent salt solution of water. This spray is highly atomized by impingement against a baffle plate and then passes over the panels.

The salt spray test simulates in an accelerated manner the severe conditions found near the seashore or aboard ship. Salt water stimulates corrosion more than fresh water, since it provides a better medium for electrochemical action.

The coatings discussed so far have all been of the type classified as fluid, non-drying coatings. Another type is the hard-drying, transparent coatings. This type is intended for use where the coating need not be readily removable. It is normally expected to act as a rust preventive only during the interval between its application and the final assembly and use of the metal parts After parts are assembled the coating may be machined off, left to wear off, or painted over with pigmented products. Where surface markings, numbers, imperfections, and so on must be visible, transparency of the coating is obviously important

The hard-drying coatings are applicable to structural shapes, boiler plates, machined surfaces, pipes, and castings, between the time of their fabrication and the time of their assembly. Every branch of heavy industry has equipment requiring this type of rust preventive. In addition, certain special uses for these materials have developed These uses include waterproofing awning, canvas, and tarpaulin stock, and treating the muslin used by sweet potato growers. One Rust-Ban of this type can also be added to oil paints, notably improving the weather resistance of the paint.

Because of the versatility of petroleum products, special coatings may be prepared for special purposes. There are, for example, compositions of asphalt in varnish solution that yield coatings having self-healing properties. Some of these may or may not contain rust-inhibiting agents Where it is desired to apply a corrosion preventive that will at the same time leave a bright surface, flake aluminum pigment may be incorporated in the fluid base. This type of coating achieves both unusual heat-resisting properties and high-heat retention. It consequently is particularly useful for coating tanks and the like, which contain material whose temperature it is desired to hold as constant as possible.

WAR AIDED THEM—Petroleum corrosion preventives are not new, but it has taken the stress of war to show their critical importance For the erection of military bases throughout the world in the early days of the war it was necesary to transport structural steel over long ocean voyages, and often to drop the steel on the beach at its destination When picked up for use the steel was frequently found to be heavily caked with rust Badly needed cargoes of airplane engines often became corroded en route to distant ports. Costly precision instruments had to be discarded because a finger-print at the factory became corrosion by the time the instrument reached the assembly line Searchlight parts were ruined by exposure to air. It therefore became important to devise a protection against the ruthless destruction wrought by corrosion.

Simultaneously with the external corrosion, serious internal corrosion was found to occur in aviation engines The highly machined interiors of engines are extremely susceptible to corrosion; and it was observed that airplane engines might show signs of becoming corroded within 30 minutes after the engine had stopped running.

Both the external and internal corrosion could be substantially overcome by the application of a variation of the coating that was used so effectively in protecting the turbines and boilers of the *Normandie*. At the present time airplane engines that are shipped abroad are carefully wrapped after having been thoroughly coated with a rust preventive. Every engine is given a test run, then disassembled, overhauled, reassembled, and given a final run. During the final run a rust preventive is injected into both the lubrication and the carburetion system, thereby coating every part of the engine with a fine protective film. Then dummy plugs, containing silica gel, are inserted in place of the spark plugs, and the silica gel absorbs any moisture present in the air in the engine. Finally, the whole engine is wrapped in Pliofilm, tied, and crated. With both the exterior and interior protected, every chance of corrosion has been eliminated.

Petroleum corrosion preventives have served an important function in preventing waste and in guaranteeing that military equipment will operate properly even after storage over long periods when exposed to the elements.

The formulation of the preventives represents the combined application of well-known fundamental physical principles and less well understood empirical relationships Factors governing the adequacy of protective coatings include surface tension, polarity, corrosion-inhibiting ability, volatility, and consistency. Some day it may be possible to explain the exact mechanism of corrosion preventives and the interplay of every factor. In the meanwhile the preventives are effectively serving the war effort, and after the war they will serve to protect the machinery of industry, the tractor and other equipment of the farmer, and the lawn mower, bicycle, saw, and general gadgets of the householder.

Meet Melamine

A New Family of Resins, Dating Back Only a Few Years, Has Invaded Fields Ranging from Textile Finishing to Complicated Moldings. High Strength, Good Electrical and Heat Resistance, and Amenability to Diversified Applications are Outstanding Characteristics for Post-War Work

By CHARLES J ROMIEUX
Plastics Division, American Cyanamid Company

JUST AS World War II broke out, a new family of resins derived from melamine* was making its first bid for public acceptance. Fortunately, these new resins were ready to meet new requirements well as old ones made acute by war conditions.

Like many other developments in plastics, this one had to await a need to bring it out of the chemical laboratory. Characteristically, the evolution of plastics is fostered by changing demands that cannot be fully met by existing products.

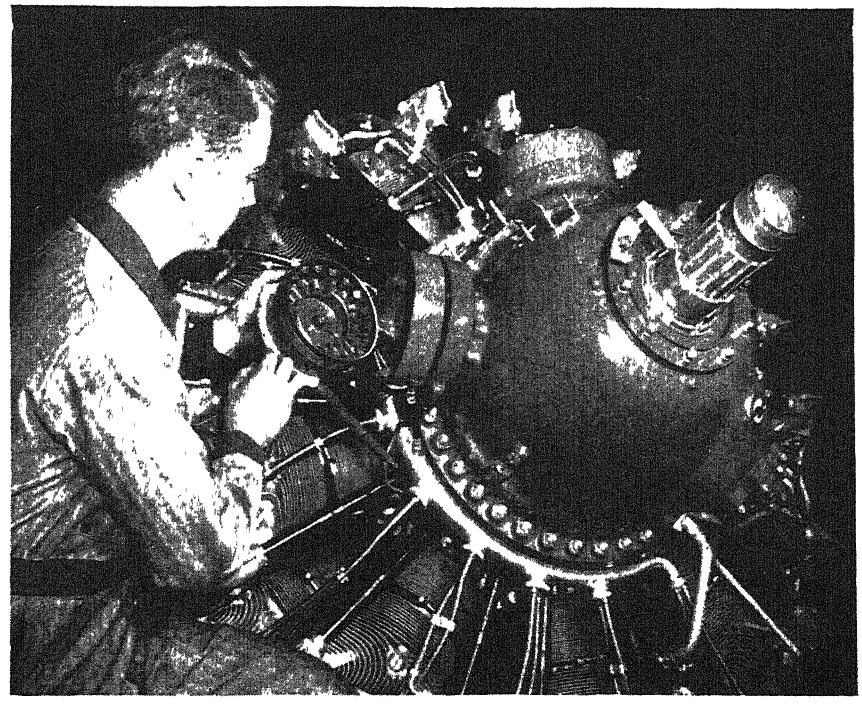
Automobile safety glass provides one of the best examples of this evolution. After World War I, a large producer of cellulose acetate sought a new source of acetic anhydride at a price which today would be very attractive. In spite of every effort, the company approached could not meet the desired cost. Side reactions interfered. One of these formed vinyl acetate for which at that time there was no market. Some 15 years later, the automotive industry sought a new interlayer for safety glass which would be better than the cellulose acetate sheet then in current use. The chemical industry, as a result of the pioneering efforts of years before, offered polyvinyl butyral produced from vinyl acetate, the very product which 15 years before caused so much trouble. Soon the vinyl derivative completely replaced cellulose acetate in safety glass.

The rapid growth in the use of the resins produced from melamine is an outstanding example of how the science of chemistry and the chemical industry have contributed to the spectacular progress of the plastics industry.

The chemical compound "melamine," $C_3N_3(NH_2)_3$, has been known for many decades; it was originally synthesized by Liebig over a century ago. It was also known that this compound could be produced from calcium cyanamide, once only a fertilizer but now parent of a growing list of important chemicals. The reaction of melamine with formaldehyde was found to yield a soluble and fusible resin, colorless and water-clear when made from pure materials. This product is hygroscopic and miscible with water and water-alcohol mixtures. When subjected to heat, or under the influence of certain chemicals, it becomes insoluble, infusible, and, as compared to its unconverted form, relatively tough. This change can occur over a wide range of acidity and basicity, in contrast to other thermosetting resins. The unconverted resin will react with alcohols to form resins soluble in a wide variety of organic solvents Furthermore, melamine resins can be used in combination with either mineral or cellulosic fillers to produce molded and laminated articles

DIVERSIFIED USES — The chemical, mechanical, and electrical properties of melamine resins are best illustrated by the considerable diversity of articles into which they have so far been incorporated and to which they have imparted certain specific and desirable properties.

Electrical equipment is an essential component of many of the weapons of modern war It must operate under conditions of service far more severe than are normally encountered in peace-time. These conditions require improved insulating materials Increased resistance to fire and heat, and to the carbonizing effect of the electric arc are particularly needed. Melamine resin in its cured form is useful in these applications since it will not continue to burn after the source of heat has been removed, nor is it readily carbonized by the electric arc. Combined with these special properties, it



Melamine resins find wide application in aircraft engine ignition parts

*See also "It's Done With Melamine," page 204, April 1941 issue of Scientific American

A plastic composition of melamine resin with a filler of chopped cotton is used in making compartment trays such as this. The composition is high in flexural and impact strength, resistant to heat and cold

is a good electrical insulator Melamine resins will also cure in contact with heat-resistant inorganic fillers, asbestos, glass, and silica Asbestos-filled molding compounds were consequently developed and have extensively replaced hard rubber and other plastics in parts of ignition systems of aircraft engines These are being used on many combat planes and have contributed to their improved performance.

At high altitudes, arcing in electrical equipment is increased by the rarity of the atmosphere, and ignition parts are frequently surrounded by corona discharges. Melamine resins perform equally well at the extremes of temperature and humidity encountered in this service, and are not damaged by the action of nitric acid, formed within ignition parts at high altitudes.

Co-operation by molders and laminators has made it possible to produce from such a new material as melamine resin the required complicated parts meeting extremely rigid specifications Many of these applications require large parts weighing several pounds and containing numerous metal inserts. Transfer molding is required in their production. Without this special technique it would hardly be feasible to produce such intricate parts.

COMMERCIALLY AVAILABLE—Melamine laminated products possessing the added advantages of arc- and heat-resistance are now commercially available for use in electric insulation. Even the fabric base material containing the resin is self-extinguishing. The glass cloth and asbestos yield products which are, naturally, more highly heat- and fire-resistant

Prior to the war, melamine resins were used somewhat extensively in paper laminates to impart hardness, scratch resistance, color stability, heat resistance, and protection against the action of cleaning agents. These laminates have been extensively used for bright colored table and bar tops. The manufacture of laminates for this type of application was discontinued with the advent of the war.

However, a similar technique has been utilized during the war to produce name plates for machines (to replace those hitherto made of critical metals), translucent instrument panels, and permanently mounted diagrams and instructions for servicing military equipment

The heat resistance of melamine laminates, particularly in translucent form, will undoubtedly expand their use in the field of lighting, and the improved weather resistance imparted by melamine will permit post-war use of laminates for exterior applications.

Other pre-war possibilities are contributing to the war effort In combination with alpha cellulose, molding compositions were developed before the war in pearl and a limited range of bright stable colors These were used for molding wash buttons, which retained, even after repeated laundering, their original gloss and general appearance. The alpha cellulose molding material was also found well suited for molding tableware where its hardness and stain resistance were advantages. The military services now utilize melamine buttons for wash garments. Light

Upper unit of this coffee maker is molded of a new melamine plastic

weight, combined with relative lack of fragility, has prompted the Navy to supply melamine molded tableware for overseas stations, light vessels, and aircraft use. A number of the molders produce compartment mess trays from a medium impact, fabric filled melamine molding composition.

Although there is no apparent relation between a heavy-duty circuit breaker for electric power lines and a mess tray, both are produced from the same fabric-filled material. This material has been selected for circuit breakers because of its resistance to shock, to arcing, and its relative fireproofness Applications of this type will undoubtedly create a considerable civilian demand. The improved heat resistance of the cellulose-filled molding material will broaden the peace-time market for plastic reflectors.

A more recent application for melamine resin is in hot-set waterproof glues for plywood and laminated wood Its outstanding characteristic is the strength of the glue line when under tension and in shear. This is combined with water resistance far surpassing the requirements for aircraft plywood

The use of melamine in glues provides an excellent example of another unique property of melamine The addition of relatively small proportions of melamine resins to urea resins produces glues of bonding quality much superior to that of the urea glues themselves.

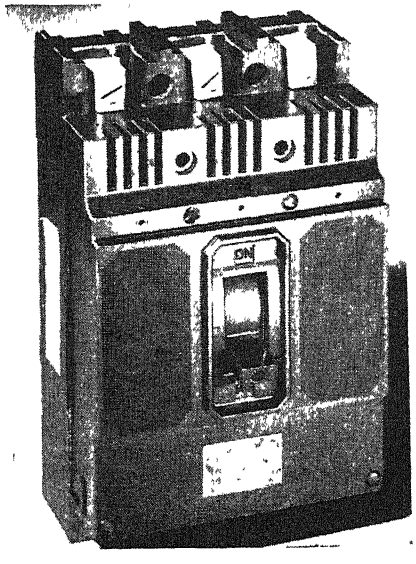
The effect of increasing additions of melamine is shown by breaking test samples in shear after 24 hours of soaking in water at 75 degrees, Fahrenheit In all cases the loadings at which failure occurs are well above the values specified for plywood bonded with urea resins. Urea resins without melamine provide a strong bond but one which under these severe test conditions usually fails before there is a break in the wood. The addition of relatively small proportions of melamine resin to the urea resin so strengthens the bond that failure occurs in the wood itself in preference to failure of the bond.

Not only do additions of melamine provide increased strength necessary to wood failure in tests carried out after a period of soaking in water at ordinary temperatures, but they also impart to the bond the desirable characteristic of resistance to boiling water.

Utilizing this property, melamine-modified urea resin glues for the hot press assembly of plywood are now on the market surpassing all requirements of Army and Navy specifications for aircraft plywood These resins provide a bond in plywood which fails only at high loading and exhibits substantially 100 percent wood failure in both shear and tension breaks

Numerous other applications outside the plastic field demonstrate the ability of melamine in small proportions to impart special properties to other products without modifying their fundamental characteristics—texture, form, color, and so on

WET-STRENGTH PAPER—Melamine resin added in small amounts to paper during manufacture imparts remarkable wet strength to the finished sheet Two samples of white absorptive paper are



Arc resistance and good dielectric properties of melamine plastics are used to advantage in circuit breakers

of similar appearance and of identical composition, except that in the manufacture of one about 3 percent melamine resin has been incorporated. This small amount of melamine resin does not perceptibly affect the absorbency of the paper. However, the untreated paper scarcely holds together when wet, but the one containing melamine resin is over 60 percent as strong wet as it is dry. In addition to imparting wet strength, melamine resin greatly improves the wet rub-resistance of the sheet Contrary to what one might expect, the addition of this resin does not embrittle the paper, but actually improves the dry tensile strength and increases many times over the resistance of the paper to repeated folding. These improvements are retained even on prolonged storage of the paper under conditions of high humidity and temperature. Paper so treated has been used for such purposes as toweling, blueprints, maps, heavy-duty paper packaging, and in numerous other applications. Melamine resins thus make paper useful in applications heretofore closed to it because of its great loss of strength upon becoming wet. Most spectacular of these is in paper packages for products hitherto packed only in drums

Another example of the use of melamine resins in relatively small proportions to impart specific properties is in the treatment of textiles. These resins, in water solutions, have been used to render fabrics creaseproof, that is, to increase their resiliency; to produce semi-permanent glazed chintz which can be laundered as those glazed with starch cannot; to act as stiffening agents in mosquito and camouflage netting; and to serve as hardening agents to modify polyvinyl butyral and other elastomers in impermeable coatings.

The alkylated melamine resins produced by reaction with alcohols have been used extensively, particularly before the war, as components of baking enamels for finishing automobiles, refrigerators, bathroom and kitchen cabinets, washing machines, and many other metal articles. In these applications resistance to heat and hardness, and the permanent light color of the finish are important In the post-war period, this application is expected to increase in volume. In these enamels, melamine resins contribute not only extreme hardness, but also to curing speed, color retention, and resistance to heat, weather, and many chemical solvents.

THE TELEVISION CONTROVERSY

By E. F. McDonald, Jr.

President, Zenith Radio Corporation

TELEVISION has cried "Wolf! Wolf!" many times in the past 14 years. The public has been fed with fables, plied with promises, enticed with the "Thousand and One Night Tales" of the miracles to be wrought. The bright stories so gaily scattered to the press on the least provocation, one after another, becomes the legends of a phantom —television.

Now comes another new problem, posed by the developments of the war. Some very pertinent questions are raised in a recent statement of the Columbia Broadcasting System. Shall television come to the public in its pre-war state? Shall television incorporate important technical improvements growing out of war experience, and launch itself in this improved state even though this may take a year or two longer? Or, shall television launch itself with two systems as some have advocated, specially those with investment in pre-war television systems at stake and those who feel we should wait not a minute longer than necessary after the war to introduce television?

Mr. Paul W. Kesten, Executive Vice President of the Columbia Broadcasting System, points out that we must start with improved television. Columbia's publicly released query, "Will pre-war television be good enough after the war?" almost answers itself.

Of course, it won't be good enough! Today research and science move at a rapid rate, accelerated tenfold by the crying necessities of war Things obsolete themselves more rapidly than at any time in our history. New processes in every field, new uses for materials, new methods, have resulted from the experiences of war. I, for one, say in regard to television after the war: "Why dig up the bones of dead pre-war television for reincarnation when there is a new baby on the way!" Shall we delay television improvements by again making a false start? Glowing promises have been made to the public of the feast to be spread before it. Let's not warm over last night's dinner to regale the hungry and expectant guest.

The Columbia Broadcasting System suggests also that it is the duty of prospective television makers, and broadcasters, too, to explain to the public that better television than the pre-war system can provide is now made possible by recent radionic developments not incorporated in the old system, and what is more, to back up explanation with action.

I agree with Columbia, or rather I should say they agree with me, for I have always pointed out to the public that until standards are fixed for television that is worthy of public support, money paid out for a television receiver is money thrown out of the window.

I agree, too, with Chairman James Lawrence Fly of the Federal Communications Commission, when he is reported as saying that he is "opposed to any move to freeze television standards at the present level." This statement is reported to have been accompanied by a criticism levelled at those who hope to sell post-war receivers that would not give the best possible service. From the words of its chairman, I know that the Federal Communications Commission will protect the public.

The idea of public service in television is hardly new, as recent announcements might lead one to assume In Chicago, television was introduced to the public in 1928 by radio station WCFL, in 1929 by the Western Television Company, and in 1930 by the *Chicago Daily News* station WMAQ Television programs were broadcast during those times. More than a thousand receivers were sold in the Chicago area. They are useless today, or had to be rebuilt as standards were changed.

In the intervening 14 years, from 1930 to 1944, there have been periodic television publicity booms, in which the public has again been urged to buy. Television receivers sold as late as 1940 shared the fate of the earlier ones Their screens remain dark unless they were rebuilt. I make this point to tell how vital it is to adopt standards embodying the important contributions gathered during the war years, so that we may have good life-expectancy in television receivers, and the public may get its money's worth when it buys one.

In the face of the experience I have just related, I ask: "Can the public be asked to accept pre-war transmission standards?" I say they cannot. Not if they believe the advertisements and the publicity stories. Not if they are conscious of the developments of the war, and the advertisements have certainly made them conscious.

The public may get pre-war automobiles, pre-war refrigerators, pre-war washing machines. You can turn these in for a fair trade-in value and they will still run and give service Not so with television sets When standards are radically changed as they again must be changed, if we are not going to throw out all that we have learned in the past few years, television is to become junk, just so much wood and wire inoperative unless rebuilt at great expense. The past has proved that.

I have stated I am against pre-war standards or warming over last night's dinner I am for starting at the farthest possible point ahead in television development. With these viewpoints I can not entertain the thought of supporting two systems of television broadcasting and reception, which have been advocated—one the pre-war system, the other the improved system.

Such dual operation would be most illogical, confusing, and would certainly be impractical on a nationwide basis when chaining operations are envisioned. Its only good point would be to create public consciousness of the better system. That investment which proponents of the old system now seek to protect, would be so injured by competition of the better system that the finger in the dike would hold but a very short time.

Someone may point out that receivers could be built to receive both systems. My answer to that one is: "It's going to be a big enough problem to build a moderate priced receiver to operate on the better system. Dual operation receivers would be costly and wasteful of the public's money."

The television problem is now again before industry, government, and public. We are on the eve of writing a pre-

scription that should serve for a long time to come. The stake in television of my own organization is great. It has been in business for over a quarter of a century on only one basis, that of being fair with the public I want television as eagerly and as soon as anyone wants it. I have everything to gain from its coming into public use quickly. But if we are not coming out with improved television after the war, the public and the dealers should be told now.

CAROTENE

Extracted from Sweet Potatoes

By Use of Acetone

RECOGNIZING sweet potatoes as an important potential source of carotene, or provitamin A, government researchers have been investigating possible methods of large-scale extraction. One of these methods, employing acetone, gave a product of 90 percent purity in a yield of about 39 percent.

The acetone extraction was carried out in four or five stages, the first two serving to dehydrate the potato pulp but absorbing little carotene. The third and fourth stages, in which a larger volume of acetone was used, extracted most of the carotene which was subsequently crystalized out—*U. S I Chemical News.*

GLASS-REINFORCED PLASTICS

Offer Possibilities for

Production Processes

SUCCESSFUL flight tests of an Army basic training plane equipped with a glass-reinforced plastic fuselage, side panels, and tail cone, have culminated a research program, initiated by the Army Air Forces Materiel Command, Wright Field, aimed at developing high-strength plastic structural materials for use in aircraft construction.

The experimental plastic fuselage is of sandwich construction. The sandwich consists of a balsa wood core between an inner and outer skin of plastic reinforced with fibrous glass cloth. Ground destruction tests of three fuselages of the same design—one of glass-reinforced plastic, one of metal, and one of plywood—indicate that for equivalent weight the glass sandwich fuselage is considerably the stronger

On a strength-weight basis the glass-reinforced fuselage is 50 percent stronger than the metal fuselage and 80 percent stronger than the wooden fuselage now in service. Firing tests have indicated that the glass-reinforced fuselage would be satisfactory under gunfire. The material did not flower and high explosive projectiles failed to detonate because of the low density of the material.

While plastics, including glass-reinforced plastics, are now widely used in aircraft construction, they have been employed in non-structural applications. The Army Air Forces and the aviation industry have sought a high strength, light-weight plastic material that can be molded into intricate shapes without high pressures, high temperatures or expensive molds, and that can be used for structural or non-structural parts

Until now the project has been closely guarded but a part of the data developed by the Air-Forces-initiated research program is being revealed in the hope that it will provide a basis for factory production of high-strength plastic structural materials. While the program was undertaken primarily because of its potential contribution to aviation, results are expected to influence developments in other fields, including the automotive, marine, and building.

The glass reinforcements employed in fabricating the laminates were heat-treated Fiberglas cloths and short, fine fibers known as Fiberglas flock. The resins were Plaskon 900, Laminac P-4122, MR-1A, Monsanto 38691, CR-39, and CR-149.

The sheets were cured at a pressure of 15 pounds per square inch in an electrically heated hot-air oven. Specimens were cut from the cured sheets and were machined and tested. Test results indicate that on a strength-to-weight ratio, glass cloth laminates possess physical properties comparable to those of a number of the metal alloys now used for aircraft structural parts

Tensile strengths were found to be proportional to the amount of glass present in the laminates, and varied from 43,360 to 54,720 pounds per square inch Compression strengths as high as 56,820 pounds per square inch were obtained. Flexural values ranged between 45,350 and 84,600 pounds per square inch. Impact strengths of unnotched specimens were from 28 82 to 31.25 foot pounds. Modulus of elasticity was 2,200,000 pounds per square inch Average specific gravity was 1.75. These values are for cross-laminated glass cloth. Strength values approximately twice as high may be obtained with parallel-laminated cloth

RAIL TRAVEL TOMORROW

Will Place Greater Emphasis

on Passenger Comfort

IT'S GOING to take comfortable, attractive, fast, and safe trains and low fares to win a fair share of the post-war travel market, railroads agree, but they have many different ideas about the specific ways of meeting the problem

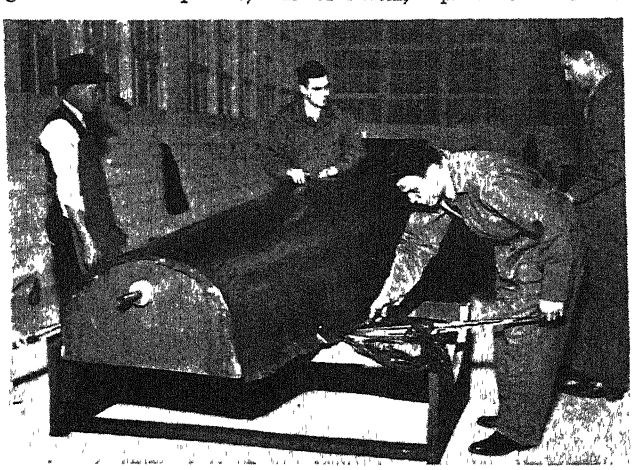
That is the substance of a recent report released by Pullman-Standard Car Manufacturing Company based on personal interviews with high officials of 71 Class I railroads owning 92 percent of the passenger cars of the country.

One subject on which there is no argument whatsoever is weight. Every road responding to the question was of the opinion that all future equipment would be of lightweight construction.

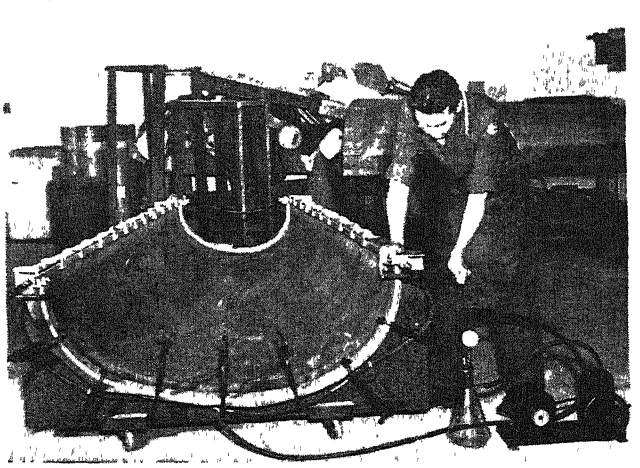
A nearly unanimous opinion in favor of standardization of equipment was returned by the roads. They felt that many benefits could be derived if at least basic cars could be standardized, thus eliminating the need for custom engineering, but they advanced no suggestions as to how this could be achieved. Car interiors, they thought, would remain individualized.

In the opinion of all respondents to the survey the most important single factor that will determine the success or failure of post-war passenger business is passenger comfort. In this category were included such items as riding qualities, reduction of noise, comfortable seats, adequate lighting, improved washroom facilities, adequate luggage space, and better heating and air conditioning.

A need for extra seat comfort is un-



Plies of glass cloth for fabricating an airplane fuselage are impregnated with resin, then laid over a male mold, and trimmed before transfer to the female mold



In the female mold the trimmed plies are covered with a rubber sheet which is sealed at the edges. By creating a vacuum, atmospheric pressure replaces autoclaves

perative, especially on long hauls, those discussing this subject declared. Three fourths of them voted for reclining seats, with a greater degree of recline on long-distance trains than on short-haul runs.

Better lighting is also needed, in the opinion of the majority. Although some held that this could best be accomplished by general overhead illumination, others thought that supplementary individual lighting was necessary.

The question of what to do about more luggage space brought a variety of answers. They included larger overhead racks, space under the seat, a compartment at the end of the car, and a well in the floor. Two roads, describing overhead racks as unsightly, would eliminate them entirely and make other provisions for luggage.

The railroads expect to stay in the passenger business and they intend to go after it with the best equipment available, according to the survey. They feel that air competition can be met to some extent on a cost basis, while the challenge of buses and private automobiles can be answered on a cost, comfort, and time-saving basis

BRITTLE STEEL

Often Results in Presence of Hydrogen

TINY amounts of hydrogen in steel, even as small as one two-thousandth of a percent by weight, can make steel brittle, and should be avoided in making metal for important war uses where toughness or ductility is essential. This is indicated by researches performed by Dr. Herbert H Uhlig, metallurgist in the General Electric Research Laboratory.

While the effect of hydrogen is evident in ordinary steel, it is exaggerated in most steels containing manganese, Dr. Uhlig says. On the other hand, certain special manganese steels do not show it. This is attributed to a different arrangement of the molecules in the lattice that makes up the metal crystals. In general where they have the arrangement known as "face centered," more hydrogen is dissolved than in the alternative "body-centered" lattice.

In the body-centered lattice, the atoms are arranged in cubes, one at each corner and one at the center. The center atom of each cube forms a corner of adjacent cubes, and so they interlock. The face-centered arrangement, on the other hand, has an atom in the center of each face of the cube, and there is no interlocking.

GLUE-LINE TEMPERATURE

Highly Important in Gluing Technique

IT IS NOT always too well recognized that temperature plays a most important part in gluing operations. It affects the working life of the glue and also the time required to develop a glue bond after assemblies have been made. With hot-press resins, it requires a definite temperature or degree of heat at the glue line to convert the resin glue. With cold-press resins and warm-temperature-setting resins, the bond is developed by a chemical reaction which takes place in the glue The application of heat accelerates this chemical action and, inversely, low temperatures retard the chemical reaction often to an extent that the resin is not converted and a satisfactory bond is not produced.

For cold-setting urea resins it is generally recognized that a minimum temperature of 70 degrees, Fahrenheit, is desirable. In fact, when gluing with cold-setting urea resins is done at lower temperatures, frequently proper water resistance is not developed. What is actually desired is a minimum temperature of 70 degrees at the glue line

Today practically all synthetic resins are formulated to meet certain government specifications and in most cases there are performance standards to be met, while in others, process specifications must be followed. The purpose of these specifications is to insure a satisfactory bond with the required water resistance so that the assemblies will meet all field requirements. It is common knowledge among synthetic resin manufacturers that cold-set bond may have good dry strength and yet be lacking in water resistance This may be true for either fresh or salt water exposure. This does not mean that the resin supplied does not meet the specification, but rather that the resin was not used in accordance with established

Bausch & Lomb 7X, 50mm Binocular

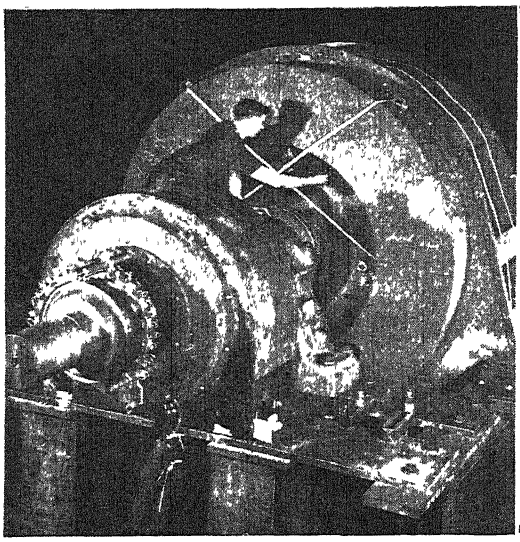
Such an increase in light transmission now means an image 50% brighter. It also means reduced internal reflections and consequent *flare*—contrast sharpened. And this can mean, in many cases, to the observer with binocular glued to his eyes, the difference between a blank wall and a clearly defined silhouette of an enemy vessel or plane.

This special Bausch & Lomb process of glass coating is permanent—cannot be injured by any attack that would not injure a similar uncoated surface. Bausch & Lomb was first in the world, more than four years ago, to make commercial use of this optical development. Every binocular produced by Bausch & Lomb—as well as the optical systems of many other B&L military instruments—has this coated surface treatment.

When you buy your new Bausch & Lomb Binocular after the war, you will enjoy this amazing light transmission advantage.

BAUSCH & LOMB
OPTICAL CO. ROCHESTER, N. Y.
ESTABLISHED 1853

Makers of Optical Glass and a Complete Line of Optical Instruments for Military Use, Education, Research, Industry and Eyesight Correction and Conservation



This giant motor, that will develop 18,000 horsepower at 514 revolutions per minute, will drive the 24-foot fan in a new Boeing wind-tunnel. In the photograph, taken in the Westinghouse shop, a workman is shown checking the temperature of the air stream which cools the inner parts of the motor when in operation

procedures for the particular type of resin.

Warm-temperature-setting phenolic resins are entering the market, particularly for marine use. It is important that these glues be subjected to properly controlled conditions, most important of which is the final temperature of the glue line. A good dry bond that has been produced at temperatures too low to fully convert the resin does not insure satisfactory water resistance, particularly for marine uses.

With some glues, and under adverse conditions, kilning after clamping is used to insure proper glue line temperature.—*L. W. Eilertsen, in "Construction Glues."*

TIME SAVINGS

As Developed by a Welding Shop Foreman

ANY method that promises to save time and makes work easier for the shop men is encouraged in the welding department of Republic Structural Iron Works. In the fabrication of welded steel bases which are designed with numerous ribs welded at right angles to steel plates, the cleaning of weld spatter was a considerable item in labor costs. This was solved by using a spatter-proof liquid, called No-Spat, which was brushed on the steel, covering about two inches on each side of the weld.

Alex Dawson, welding foreman, decided that brushing was too slow so he designed a simple air-operated spray to eliminate the brushing Obviously, when the steel base was sprayed a larger surface was covered by the No-Spat liquid. This led to an even more important time- and labor-saving discovery.

After these bases are fabricated they are placed in a furnace, given a stress-relief heat treatment and then cooled slowly in still air. This treatment removes shrinkage stresses in the welded steel. But this treatment also leaves an oxide film on steel and seems to make mill scale harder to remove. Dawson noticed that surfaces covered by No-Spat left the mill scale much looser on the steel and the oxide film was much easier to remove. Now all steel structures are sprayed completely before and after welding Even though they may remain in an open yard for several days, waiting their turn to go in the furnace, the surface is protected from rusting Instead of the usual three-hour cleaning time per base after heat treatment, the time has been reduced to 1¾ hours and a much cleaner and smoother surface remains to receive the priming coat of paint

WIND-TUNNEL MOTOR

Uses Magnetic Coupling to Vary Speed of Fan

AN ELECTRICALLY driven hurricane—a powerful flow of air which may travel nearly as fast as sound—is helping Boeing aeronautical engineers design future descendants of the famous Flying Fortress for war or peace-time use.

Power center of this man-made gale is an 18,000 horsepower electric motor which, while capable of developing as much power as 225 automobile engines, takes up little more floor space than a single five-passenger sedan. It has been installed to drive the fan in the concrete wind tunnel where Boeing engineers will investigate the behavior of planes, wing shapes, airfoils and other parts or sections of aircraft, at any desired speed up to approximately 700 miles an hour. Sound travels about 741 miles an hour in dry air at a temperature of 32 degrees, Fahrenheit.

At top speed, the rotor—rotating central portion—of the Boeing wind tunnel motor revolves 514 times a minute to turn a multi-bladed propeller-like fan 24 feet in diameter in the back section of the tunnel. Tips of the 16 fan blades at this speed are traveling more than 442 miles an hour.

The motor is connected to the fan by a magnetic coupling and a 10-ton steel shaft 37 feet long. Motor, shaft, propeller hub, bearings, electric power transformers, and much of the other electrical apparatus for the tunnel, were made by Westinghouse. The magnetic coupling and its control were supplied by the Dynamatic Corporation.

By using the magnetic coupling, it is possible to vary the fan speed while the motor continues at a steady pace. Inside the coupling are two revolving metal rings, separated by an air gap and having no mechanical connection. The ring on the motor side is electro-magnetized so that when it turns it pulls the other ring around in the same direction, thus transmitting power from the motor to the fan shaft through air.

By increasing the amount of electricity passed through the electromagnet, its pull on the fan shaft ring is stronger, hence more of the motor's power goes into turning the fan Thus the speed of the fan and the speed of the air stream in the tunnel can be controlled without varying the speed of the driving motor. When the propeller speed is reduced, the extra power produced by the motor is converted into heat in the coupling, and is removed by water flowing through the coupling jacket

STEEL MILLING

Improved by Reducing Number of Cutter Teeth

IN MILLING steel with cemented carbides, one of the most important considerations is the selection of the correct number of teeth on the cutter Since increased cutting speed means more cubic inches of metal removed per minute, and therefore greater power consumption, it frequently becomes necessary—due to power limitations—to reduce the load in some manner. It usually proves to be better practice in such a case to reduce the number of cutter teeth rather than either the feed or the cutting speed. Maintaining sufficient feed per tooth is important in steel cutting—particularly in roughing—to provide both sufficient tooth loading and adequate load distribution back of the cutting edge.

This is well illustrated by a typical milling operation on steel parts. This concerned the milling of master connecting rod steel forgings by six-inch diameter inserted blade face mills having 14 cemented carbide-tipped blades. The cutters used were standard type face mills operated at a peripheral speed of about 400 feet per minute and with a feed of .0015-inch per tooth. After milling about ten connecting rods, the cutting edges were chipped badly, several of the cemented carbide tips being in such a condition as to make desirable the installation of new blades. This meant that after the damaged blades were replaced, the blades had to be re-set in the proper relation to each other and extra time had to be spent in grinding to put the cutter in good working order again

An examination of the less damaged cutter teeth showed that the light feed for each tooth being used had increased the width of the "wear land" behind the cutting edges sufficiently so that the increased pressure due to dulling of the cutting edges was beginning to cause portions of the cutting edges to chip out.

In an attempt to increase production per grind and to cut down the time spent in repairing the damaged cutters, every other tooth was removed from

each cutter. The remaining teeth were then resharpened exactly as they had been previously, an operation requiring a relatively shorter time than before. The same speed in feet per minute and the same table travel in inches per minute were used in these trials as had been previously employed. This, however—due to the number of teeth which had been removed—resulted in a feed of .003-inch per tooth rather than the original feed of 0016-inch per tooth.

The increase in feed per tooth enabled the cutters to machine some 30 connecting rods per grind instead of the previous total of ten. On inspection, the cutters showed merely a normal dulling of the teeth. No chipping of the cutting edges and no broken teeth were in evidence. The teeth required only a slight "touch up" with a diamond impregnated grinding wheel to put them into first-class condition again

Furthermore, with this change only three face mills per machine were needed to keep the operation going, one cutter being on the milling machine; one at the milling machine ready to be used; and the third in the grinding room being re-sharpened

ROCKET POWER

Has Bright Future, Says Authority

POST-WAR industries will spring from wartime development of rockets, jet-propulsion planes, and gas turbines, according to G. Edward Pendray, a founder and former president of the American Rocket Society, who recently told the New York Electrical Society that the size of these new industries will depend largely upon the progress that scientists and engineers are able to make during the remainder of the war.

"There is nothing fantastic about rocket power any more," he said, "and the rocket is no longer merely an entertaining addition to a fireworks display. The rocket gun has been made a deadly weapon. The bazooka and the Russian Katiusha knock tanks out of battles while the Germans mount similar guns on their fighter planes in an attempt to smash the formation of our bombing planes.

"The jet-propulsion motor, close kin to the rocket, has been brought to the point where both Britain and the United States are using it as the power plant for fighter planes. And the gas turbine is maturing so rapidly that in a very few years we may see it driving planes, locomotives, and electric generators."

Eventually, Mr. Pendray said, rocket power may enable man to build a 1500-mile-an-hour plane which will whisk a businessman from a Montreal breakfast to lunch in London and have him back in Canada by nightfall after an afternoon conference in the British capital.

"But before that day arrives," he said, "the rocket will have to go through a long series of improvements. In the meantime it will do many less thrilling but just as useful tasks—for example, assisting conventionally powered planes during the take-off. A plane can fly with a 50 percent greater load than it can lift off the ground with its own engines. Rockets, therefore, may increase each payload of bombs, passengers, or cargo by several tons. Weather-rockets carrying radios may be shot into the upper air at hundreds of points to provide forecasters with instantaneous and highly accurate reports about the huge masses of air that govern the climate on earth."

The gas turbine, a multi-bladed "windmill" driven by a blast of hot, rapidly expanding gases created by burning oil or gasoline, may eventually replace the conventional reciprocating gasoline engine in very large airplanes, Mr. Pendray said.

"For war planes and transports, we are now building gasoline engines of 2000 horsepower or more," he said, "but those power plants are rapidly approaching their maximum practical size. They are made up of thousands of finely machined, costly parts which require constant maintenance and replacement.

"The gas turbine promises to step in at the point where the gasoline engine leaves off. Although it is a simple machine, the turbine can deliver large amounts of power dependably and efficiently."

The ultimate field for rockets and jet propulsion will be in super-stratosphere planes of the future, he said.

"Both the gasoline engine and the gas turbine require oxygen to support combustion," Mr. Pendray explained,

Ingenious New Technical Methods

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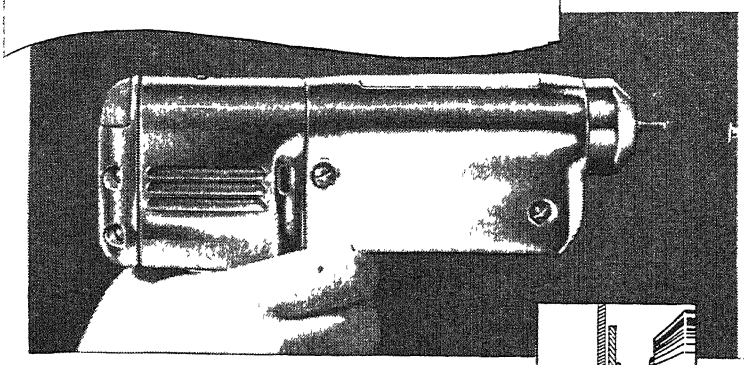


New Air Tool Drives "blind" Rivets Accurately... Automatically

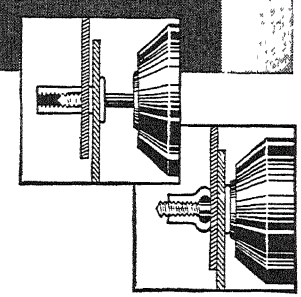
Installing "blind" RIVNUTS quickly with precise, positive upset while working entirely from one side is now possible with the recently developed Auto RIV-Driver. Completely automatic, the tool runs a threaded mandrel into a Rivnut, upsets it, backs the mandrel out and stops the tool. Operators simply press a throttle; make no manual adjustments for any operation. Rivnuts are installed 6 to 8 times faster than formerly; rejects are almost completely eliminated.

The tool can be adjusted to upset at any depth required. Once set, adjustment is tamper-proof—every Rivnut is driven accurately and uniformly An indicator on the tool handle lights when the upset is correct; does not light if Rivnut is improperly headed.

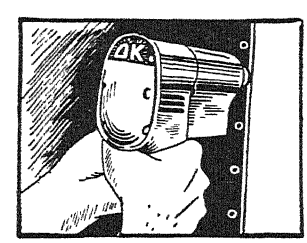
Powered by compressed air, the Auto RIV-Driver weighs just 4¼ pounds; is 9½ inches long; balanced for efficient handling by women operators.

You all know that our fighting men need the finest quality materials that we here at home can produce. That goes for Wrigley's Spearmint, Doublemint and "Juicy Fruit" chewing gum, too. Our stock pile of raw materials that goes into the making of Quality chewing gum is getting lower and lower. Until we can again build up our raw material inventory, we are sending all of our limited output of Quality chewing gum to our fighting men and women overseas, only.

You can get complete information from the Independent Pneumatic Tool Co, 600 W. Jackson Blvd, Chicago 6, Ill

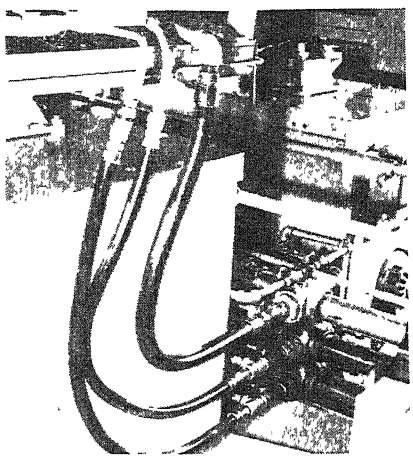


Rivnuts (mfd. by B. F. Goodrich Co.) are internally-threaded tubular rivets which can be installed "blind" while working entirely from one side of the job.



Automatic action, positive depth control and visual indicator assure correct and uniform installation of rivnuts with new Auto RIV-Driver

Y-117



Above: Hoses made of a synthetic resin are important parts of this stand for testing automatic pilots. Right: These flexible hoses withstand hydraulic pressure and flexing

"while the rocket packs its own oxygen in the explosive mixture that is its fuel Even more important, man may eventually travel at extreme heights where there is not sufficient atmosphere for propellers to bite into or for wings to push against."

RESIN HOSES

Solve Problems in Production Testing of Instruments

TWO SMALL instruments responsible for precise aerial navigation—the Sperry directional gyro and gyrohorizon—together form the gyropilot which automatically keeps a plane in level flight and on steady course The unvarying performance of these vital gyroscopic instruments must be absolutely dependable, and to assure this dependability spot-checking of instruments will not suffice. It is necessary to test each instrument, each component part of it, as well as each function it must perform.

Description of one item will illustrate the painstaking search that Sperry has made for the material best suited to perform each particular function in the testing procedure. This item is the hose used for all connections on test stands. Five years ago, after a long process of elimination, it was found that a hose with a core of compar, a vinyl resin derivative developed by Resistoflex Corporation, was the only hose capable of meeting satisfactorily the rigid requirements of production testing. Compar hose, the same as that used in many installations of gyropilots in aircraft, now is the only line used by Sperry in testing of gyropilots. Not only does it meet the demands of an oil-proof flexible hose that is impermeable to oil; it is so wear-resistant that in some cases a single line has served for the entire five years without showing signs of bulging and without loss of tensile strength or flexibility.

In testing instruments for torque, hammer pressures between 150 and 200 pounds are exerted upon the short flexible line 12 times every minute Hammer pressure, which is the sharp, almost instantaneous increase in the pounds per square inch exerted against the wall of the hose by the hydraulic oil, has a tendency to cause hose expansion and to aggravate the effect of oil flow. With the oil flow varying from 18 to 3 gallons per minute at a temperature around 135 degrees, Fahrenheit, the compar hose can be seen to writhe under the sudden pressure exerted upon it, but without any loss in tensile strength.

Added to this rigid requirement is the need for a short flexible line that will retain its flexibility despite constant coupling and uncoupling, with resultant splashing of hydraulic fluid Lines must be bent on a five-inch radius to permit cleaning of machines and to make certain connections at sharp angles. In testing gyro control units, a number of them are secured on a large oscillating platform. Simulating the conditions in flight, this platform rolls, pitches, and yaws, causing a constant flexing of the short hose.

Another problem reported solved by the adoption of plastic hose is that of erosion. Formerly instruments had been rejected frequently for malfunction during tests. It was found that minute flecks or particles had become removed from the inside of the hose by the high velocity of the oil flow and had been trapped in sensitive mechanical elements of the system. This condition of erosion was rendering instruments inoperative, but was immediately beaten when compar hose was adopted

AERIAL SURVEYS

Yield Information of Value to Engineers

IF YOU want to know what's under the ground, go up in an airplane to find out, is the advice of Fred Grieme, Chief of the Civil Aeronautics Administration Airport Development Section.

Aerial photographs can reveal to the trained engineer soil characteristics which may be all-important in the choice of an airport site, as proved by successful tests at some 25 CAA airport construction jobs.

By the interpretation of aerial photographs alone, it can be determined what the soil texture of a particular area is —whether clay, silt, sand, or gravel— and whether its natural drainage is good, poor, or non-existant. These two factors are vital to choice of an airport site which will not require expensive fill initially or rebuilding of unstable runways later

Approximately $150,000 was saved by use of aerial photographs at one CAA airport project, according to Mr Grieme Estimates had indicated that it would be necessary to pay a high price to bring gravel to the airport site, until study of photographs showed that there was a large deposit beneath the surface on a nearby farm. The owner believed that the CAA representatives were crazy when they made an offer for the gravel pit which he didn't know existed on his farm A little digging confirmed their assumption

Use of aerial photographs supplements rather than replaces actual soil tests, Mr. Grieme points out. Borings are still necessary for obtaining detailed information such as depth of various strata and bearing strength Preliminary study of aerial photography, however, is a more economical method of selecting a site and locating the runways on stable soil than making innumerable borings. General practice at present is to make borings only after runways have been laid out. Sometimes this results in runways which need continual patching, when aerial photographs might show that placing the runways 200 yards away would eliminate this difficulty

RUBBER SECRETS

Solved by Use of the Electron Microscope

NATURAL rubber, it has long been known, can be separated by suitable solvents into two parts, or fractions, which differ in their comparative runiness, or viscosity. The fraction of less viscosity is considered to have lower molecular weight, and is called the sol. That of greater viscosity and higher molecular weight is known as the gel Rubber mixtures in which the sol constituent is greater are more plastic or putty-like than mixtures consisting mostly of the gel fraction, which are tougher and more elastic. The process of vulcanizing is basically one of converting much of the sol fraction of natural rubber into gel, thus making the material longer wearing in such applications as tires.

Theoretical explanations for these differences are numerous It has remained for the electron microscope. however, to give direct visual evidence on which more thorough-going explanations may be based.

Utilizing techniques developed in the biological laboratories of the Massachusetts Institute of Technology for the employment of electron microscopy in investigating long-chain molecules

characteristic of protein fibers such as muscle, a research group at the Institute under the direction of F. O. Schmitt, has ascertained facts about the structure of rubber which go far toward showing how and why natural rubber gets its valuable property of elasticity

The extremely high magnifications obtainable with the electron microscope —as high as 100,000 diameters were used in this study—make it possible for the researchers to look into the innermost structure of rubber and thus to see directly the physical situation which hitherto could be visualized only in theory. The work of the Technology group, which also includes E. A Hauser, D. S leBeau, F. O. Schmitt, and P. Talalay, was reported in a paper to the American Chemical Society by C. E. Hall, entitled "Electron Microscope Studies of Natural and Synthetic Rubber Fibers."

When fine fibers of rubber are analyzed by electron microscopy, the paper stated, the long, flexible molecular chains composing the rubber are found to be of two structures. The first consists of single thread-like filaments, along which are strung rounded nodules Both thread and nodules, of course, consist of rubber molecules In the nodules, the groups of chains are bound by so little cross-linking of one chain to another that they may slip freely over and about each other, so freely in fact that the nodule may be referred to as "fluid."

The second kind of structure which the molecules may form is a highly branched network of filaments, criss-crossed and cross-linked into a tight-meshed maze, with fine beadlike knots of material strung along the meshed fibers. The molecules making up these beads are packed far more closely than are those composing the nodules of the first type of structure, and they are cross-linked to each other. Consequently, they cannot slip about each other freely, and rubber in which this second structure predominates is therefore far tougher and more resilient than is the softer, putty-like rubber composed principally of the "soupy" nodular structure.

The sol fraction of natural rubber, these studies have shown, consists mainly of nodular structures of the first type. The gel fraction has been found to consist entirely of the beaded networks of the second structural type In these findings is the electron microscopic explanation of why sol rubber is putty-like and plastic and why gel rubber is tougher and springy.

From the point of view of manufacture, these findings are significant. Before it is vulcanized for the production of tires or other goods, natural rubber is milled, or ground. The milling process breaks down the gel portion of the original rubber, increasing the sol portion and bringing the whole nearer to a completely plastic or putty-like state in which it can easily be molded to desired shapes. The vulcanizing process which follows has as its primary purpose that of driving the loose sol portion back to the tighter gel state, increasing the proportion of gel by decreasing the proportion of sol, and thus bringing the whole back nearer to a nonplastic, nonputty-like, elastic condition That this is the result of the process of vulcanization is demonstrated by the electron microscopic studies, which show vulcanized rubber to consist almost wholly of gel structures

AIRCRAFT PUTTY

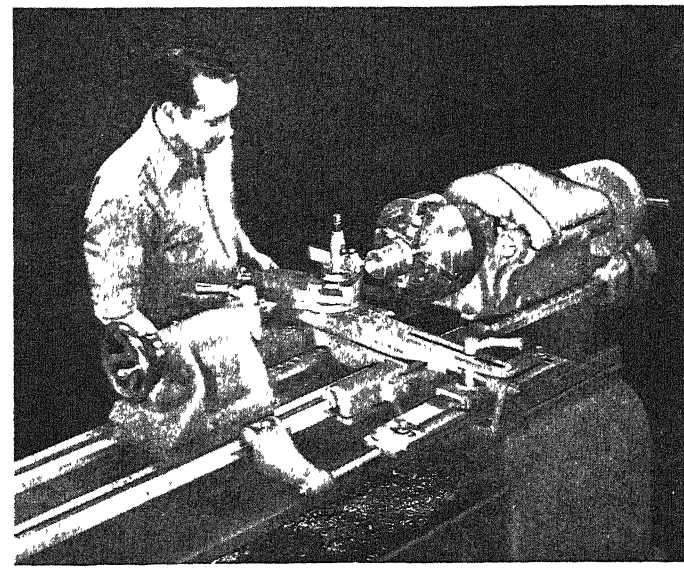
May Find Application for Other Purposes

ALTHOUGH Army planes have shed their relatively rough coats of camouflage paint, the aerodynamic dream of perfect wing-surface smoothness is yet unrealized. An important step toward the irreducible minimum of "skin friction" is seen, however, in a flexible, high-adhesion aircraft putty which has been developed by Du Pont for filling dents and cracks between riveted aluminum sheets forming aircraft wings

So important is wing-surface smoothness in fast fighter planes that it has been seriously suggested they be wiped free of dust and other small particles by service crews before each takeoff Some idea of the toll taken by any departure from smooth-as-glass surfaces may be had from the Langley Field report that a transport flying at 225 miles per hour expends 180 horsepower pulling rivet heads and lap joints through the air

Aircraft putties heretofore in use either shrank considerably, became brittle with age, or were not flexible enough to withstand vibration, particularly at the low temperatures of the stratosphere. Also, finishing operations were retarded because previous putties dried slowly. Synthetic resin types stick to the putty knife during application.

The new Du Pont aircraft putty, it is reported, has a buttery consistency and stays in place. It displays no tendency to flow and therefore maintains the desired surface contour It does not sag on vertical surfaces. Both fast-drying



Precision —

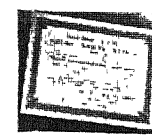
THE DISTINGUISHING QUALITY OF SOUTH BEND LATHES

It is for their high precision that South Bend Lathes are best known. Their dependable accuracy has made them first choice for the most exacting work in hundreds of essential war production plants. Finish turning and boring operations are often performed with such exactness that subsequent grinding, honing, or lapping is unnecessary.

In war production, there is no place for equipment that can not hold required tolerances or deliver the maximum output. Investigate the possibilities of South Bend Lathes for handling your exacting jobs with greater efficiency. With them, you will find it easier to maintain precision tolerances on toolroom and production operations.

POST-WAR PRIORITY PLAN

To those who cannot qualify for a war-time priority, South Bend Lathe Works offers a practical Post-War Priority Plan You can place your order now for any South Bend Lathe. No deposit or down payment is required. We ask only that the order be placed in good faith. When civilian production is resumed, orders will be filled in the sequence established by the numbers of the Post-War Priority Certificates. Should conditions necessitate, the order may be cancelled at any time.



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and exceptionally low in shrinkage, the putty weighs about one fifth less than conventional putties, always an important factor in aircraft.

Now available only for war uses, the new aircraft putty is expected to have post-war value for such applications as the finishing of rough metal castings and railroad coaches

QUARTZ FILAMENTS

Used as Gages in the Electron Microscopes

THE CROSS BOW, storied weapon of medieval times, is being used by research engineers as a helpmate to one of the most modern of scientific instruments, the electron microscope.

Fashioned from tough, flexible steel and mounted on a wooden stock, the

An ancient weapon, the cross bow, now draws delicate quartz filaments

cross bow shoots an arrow that draws out quartz filaments so fine it would take 60 of them to make the thickness of a human hair The filaments, 1/30,000 inch in diameter, are used to calibrate the magnifying power of the electron microscope

"To make such a very delicate thread," explains Dr. Alois Langer of the Westinghouse Research Laboratories, "requires a high initial burst of speed that 'spins out' the quartz while it is in a hot, fluid state and before it has a chance to cool and harden. The cross bow is about the simplest and most efficient instrument for doing this."

Since the electron microscope magnifies objects many thousands of times, scientists need a very minute "measuring stick" by which to gage its power. A human hair, for example, seen under the microscope at its greatest magnification, would resemble a cable almost two feet thick.

Some of the filaments drawn by the bow are so delicate that they are invisible to the naked eye when viewed under direct light, the engineer reports. In order to be seen they must be held at eye-level against a strong light. The light glances off the shiny filament, scattering its rays in different directions and making the filament appear much larger than it actually is

When the Westinghouse engineer wants to replenish his supply of filaments, he places the cross bow in firing position and attaches a small, cylindrical piece of quartz to the end of the arrow Using a very hot flame from an oxy-hydrogen torch, he heats the quartz until it is just about to melt

Then he pulls the trigger. The arrow darts from the bow at high speed, trailing behind it gossamer-like threads of quartz Unbroken pieces up to 20 feet in length are not unusual, but more often the filaments are dispersed in smaller sections throughout the route the arrow takes. They are extremely flexible and can be wound round the finger like thread.

To measure the actual thickness of the filament, it is first put under the electron microscope and gaged by other methods of comparison. Once its diameter has been fixed accurately, it becomes a "measuring stick" for determining the magnifying power of the electron microscope.

X-RAY INSPECTION

Expedited by Compact Equipment

A SAFE, self-contained, easily operated x-ray unit for industry is designed for inspection of parts, assemblies, and finished products of metal, hard rubber, plastics, ceramics, dielectric materials, and so on. It makes possible taking of high quality sharp radiographs quickly by plant personnel under controlled conditions, without the expense of a skilled x-ray technician or the cost of a lead-lined room.

The Searchray Model 150, as the unit is called by North American Philips Company, Inc, is simple to operate because of fixed milliamperage over the entire kilovoltage range. An electrical interlock, which interrupts the circuit while the radiographic compartment is open, eliminates any danger to the operator from x-radiation.

Searchray has a continuous kilovolt regulator which permits adjustment during viewing operation at any point from 0 to 150 kilovolts, so that, depending on density and thickness of the part under observation, greater clarity on the fluoroscopic screen can be obtained. The apparatus can also be set for correct metal thickness on a direct reading scale when radiographs are to be taken. A cassette tunnel at the bottom of the radiographic compartment makes possible the insertion and removal of x-ray film or paper without disturbing the position of the object.

Under this cassette tunnel a fluoroscopic screen is mounted. The image of the object can be viewed in a mirror through a folding eyepiece. The operator looks into this while seated in front of Searchray. This facilitates the positioning of an article before taking a radiograph

Simplicity of operation is one feature of a new industrial x-ray unit

RUBBER PRODUCTION

Merits of Two Natural Sources Being Tested in Haiti

HAITI, a proving ground for commercial development of natural rubber production in the Western Hemisphere, expects to be producing hevea sheet rubber at the rate of at least 1600 tons a year by 1954.

This estimate of Haiti's prospective hevea rubber production is made in a report on the island republic's expanding rubber operations by "A Propos de SHADA," publication of the Haitian-American Agricultural Development Corporation (Societe Haitiano-Americaine de Developpement Agricole), better known as SHADA from the initials of its French name.

SHADA has been harvesting rubber from 90 acres of rubber trees that were planted at Bayeux in 1903 by two Belgian brothers, Fritz and Max Hermann There are 700 hevea and about 5000 castilla trees Although around 1914 there was some tapping of these trees, the first interest in rubber died out and since then they were left untended and utilized as shade for cacao until April, 1942, when SHADA resumed tapping of these trees.

SHADA, however, is counting for its major share of hevea rubber production on some 3200 acres of new hevea trees, now eight feet tall, growing in the Bayeux area. From these trees it expects to get 1600 tons of hevea sheet rubber a year by 1954.

The merits of the quick-growing cryptostegia vine are being weighed with those of the slower-growing hevea tree to determine the better long-range source of natural rubber. The cryptostegia vine can be tapped within a year after planting. In the case of hevea, however, the tapping is not usually begun until the trees are eight to ten years old.

"SHADA believes that rubber has a real future in Haiti," says "A Propos de SHADA," in commenting on the test between latex-yielding vines and latex-yielding trees

"If soil, climate and other conditions prove as favorable as we expect them to be, our plantations at Bayeux and Grand Anse may be but the beginning of hevea rubber production in Haiti.

"Indeed, the coming decade will offer an interesting race between the merits and economic value of hevea and cryp-

tostegia as sources of rubber for Haiti, even though our main project is now quick-growing cryptostegia whose wartime crops can be harvested while the slower tree rubber is growing up"

SOYBEAN OIL
Production Increased by New Varieties

FOUR FIFTHS of the fats and oils the United States imported in pre-war years will be replaced by the oil from the home-grown crop of soybeans, according to figures developed by Dr M. A. McCall of the United States Department of Agriculture in a recent review of some of the services of the scientific crop improvement activities of the Department and the state agricultural experiment stations.

"The critical wartime fat and oil situation has given added pressure for soybean production," he said. "In 1941 the acreage harvested for beans was 5,855,000 acres; in 1942, it was 10,762,000 acres; 11,492,000 acres were estimated for the 1943 harvest; and a goal of 14,000,000 acres has been requested for 1944 The increase in the production of this crop as a wartime necessity has been remarkable.

"Newly introduced varieties maturing satisfactorily in the several areas, yet utilizing the full growing season and higher in oil content than others previously available, have been a contribution to our war economy hard to overvalue.

"The 14,000,000 acres of soybeans requested for 1944, estimated to produce 17.3 bushels to the acre on the average, should give 242,500,000 bushels of beans of which 180,000,000 should be available for crushing This should produce 1 6 billion pounds of oil"

TOOL LIFE LENGTHENED
By New Method of Chromium Plating

A METHOD termed "wholly new in metallurgy" which lengthens the life of cutting tools from two to fifty times by means of chromium plating and an after-treatment of soaking in hot oil at 350 degrees, Fahrenheit, for an hour, was described before the American Society of Mechanical Engineers by Axel Lundbye, Chief Engineer of the Crowell-Collier Publishing Company.

Mr. Lundbye, originator of the Lundbye process, explained that plating chromium onto steel, with the after-treatment to release hydrogen, results in the chromium becoming an integral part of the underlying material. The process avoids the peeling and scaling from the base metal when pressure is applied. This had formerly prevented wider use of effective plating. He stated that, by chromium plating blades only a few micro-inches thick, and giving them the oil treatment, the life of the blades was increased from 8 hours to 110 hours minimum. Many companies have found, he declared, that tool life has been increased two, three, four, and up to fifty times.

Several hundred manufacturers are now using this process in their plants. It is especially adapted to tools and machine parts which are subject to wear, corrosion, bending, shock, and heavy load. The process results in an increase in the wearing quality of machine parts, less friction, and easier and smoother operation.

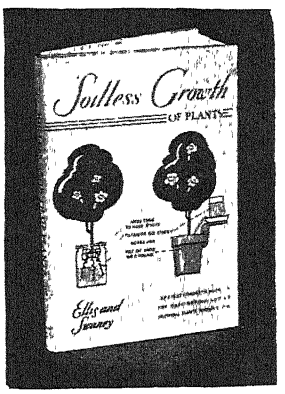
PLIABLE FABRIC
Can be Used in Ventilating Ducts

MILLIONS of man hours have been saved, and practically all metal has been eliminated from heating and ventilating air-duct systems of aircraft by the development by United States Rubber Company of a fire-resistant asbestos product made of less critical ingredients. Welding, die casting, riveting, intricate metal processing, pattern making, leather and fabric pipe covering, and metal forming, previously all essential musts in the building of these systems, have been eliminated.

The development of this pliable fabric has made possible high speed production schedules in the aircraft industry for it can be twisted and turned or completely deformed, yet easily returned to its original shape without effort.

The simplicity of construction and the ease of application and installation of this new system allows this material to be formed into radii and intricate

SOILLESS PLANT GROW. HAS GONE TO WAR, TOO!



SEVERAL years ago hydroponics, or "soilless growth of plants," was designated as one of the outstanding developments of the age. The truth of this prediction is proved by the many ways in which soilless growth is serving the war effort.

In many places where weather or geographic conditions make regular gardening impossible, fresh vegetables are being grown without *soil* for Army and Air Corps personnel. As the conquest of Pacific islands proceeds, hydroponics will be increasingly used; it was in fact well established on Wake Island long before Pearl Harbor

Soilless culture is also playing a vital part in industrial research. The Goodyear Tire and Rubber Co. is experimenting with new types of cotton fiber for use in tires. The plants are grown in greenhouses by the soilless method, which permits the exact control of nutrient conditions so essential for scientific work

Learn more about this simple, productive method! *You* can have a soilless Victory garden at negligible expense! This is the first and still the most widely read book on all phases of the subject Plant requirements, formulas and explicit directions are given in

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Plywood demand is skyrocketing in the production of wartime housing, airplanes, boats, and other defense needs, yet specific information on the material itself is difficult to find. Here, between the covers of a plastic-bound book, has been gathered technical information on all phases of plywood manufacture, specially written for engineers, designers, and users of plywood. (249 pages, 5 by 7½ inches, tables and drawings.)—$2.50 postpaid.

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angles and shapes for fittings in a matter of minutes It eliminates the necessity of making patterns and bending and fitting joints and elbows with strategic materials. These systems are assembled and cemented together with a special synthetic rubber compound

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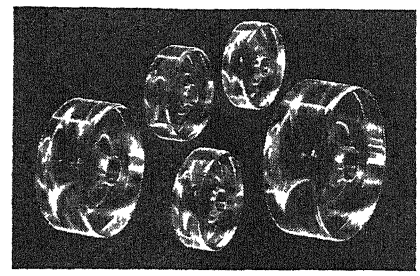
THEY LOOK like streamlined roller-skate wheels, but they're actually molded glass bearings no bigger than



A miracle of molding—glass bearings as small as the head of a pin

the head of a pin. Enlarged hundreds of times in the accompanying photo, the smallest bearing is about .006 inch in diameter. Developed to replace sapphire bearings formerly produced by Swiss craftsmen using horsehairs as drills, they support spinning metal parts in miniature General Electric communications and aircraft instruments for the armed forces

VULCANIZING SYNTHETIC RUBBER

Improved Through Use of New Agents

SINCE the general-purpose synthetic rubber, GR-S, made its formal debut, chemists have been concerned with two vital problems: They have striven to improve the tack of this polymer and to achieve precise control of its vulcanization

Extensive tests have shown that alkyl phenol sulfides serve the dual purpose of imparting tack and acting as vulcanizing agents for GR-S rubber. One method of imparting tack to synthetic rubber has involved the addition of organic materials. To overcome the second problem, the approach followed by rubber chemists has been the correct choice of accelerators to be used with sulfur vulcanization as well as careful adjustment of quantity used.

p-tertiary-amylphenol-disulphide is an example of the alkyl phenol sulfide class of vulcanizing agents which mixes readily with synthetic rubber of the butadiene type to impart upon vulcanization superior tensile strength and improved elongation, together with greater resistance to tear and cracking under flexure. All these factors contribute to the improvement of GR-S synthetic rubber.

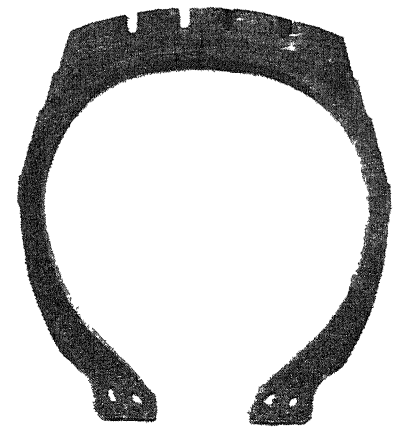
The improved synthetic rubber compositions made available through the use of these new organic vulcanizing agents are outstandingly resistant to deterioration by heat and, as such, give promise for such applications as inner tubes and the carcass section of tires These agents, by virtue of both their tack-imparting quality and vulcanizing power, are proving of interest in the formulation of rubber footwear stocks They are also adapted to the manufacture of improved synthetic rubber goods for industrial uses

The basic raw materials used in the manufacture of the new vulcanizing agents are readily available. Marked improvement in the present synthetic rubber, without changing the present method of manufacture, may be realized through use of alkyl phenol sulfide vulcanizing agents

TRUCK TIRE

Life Extended by Improved Design

NEW design and construction of a Goodrich truck tire make it run cooler than ever before Reduced tread thickness at the shoulders and addition of new ventilating grooves in the shoulder blocks, are the principal changes in the tire construction which



Cross-section of the new truck tire, showing shoulder ventilating grooves

lessen operating heat, while other improvements in design reduce dangers of sidewall cracking. The sidewall has been made thicker at the base of the grooves between the shoulder blocks, and the ornamental rib on the sidewall constructed shallower to provide better distribution of stresses

INDUSTRIAL TELEVISION

Can Serve to Improve Process Control

POTENTIALITIES of television as a new and effective aid to industry after the war have been described by Ralph R Beal, Assistant to the Vice President in Charge of RCA Laboratories, who envisages television as the coming "eyes" of factories, the "means of coordinating activities in giant manufacturing plants, and the means also of peering into places and situations that might be inaccessible or extremely hazardous to man."

"We know now," the research engineer declares, "how it can be used to

extend the eyesight of the plant manager to critical operations that ordinarily would require much time and effort to reach for personal inspection or which might even be inaccessible—how television can aid immeasurably in plant control

"Television cameras at strategic points can be connected by wire to receivers where production experts, foremen, and supervisors can follow the flow of fabricated or raw materials and watch the progress of the work. Such setups will be particularly valuable in mass-production assembly lines, and they may be extended to include loading platforms and shipping rooms"

According to Mr. Beal, television cameras may be used in connection with chemical reaction chambers, making visible to the operator without personal risk the chain of events occurring in complicated chemical production units, and thus enable him to control the process with optimum results. He says that specially-built cameras may be used in furnaces to observe steps in the formation of alloys, and that others may solve vital problems of analysis in important industrial processes

CAUSTIC REMOVAL

Facilitated by Use of Bicarbonate of Soda

REMOVING excess caustic from goods in various textile finishing operations by a new process makes use of bicarbonate of soda instead of sulfuric acid, which has been employed heretofore It is claimed that the new process makes unnecessary the use of acid-resistant equipment, minimizes hazards to workers, reduces the number of steps in some processing operations, and improves the quality of the goods.

The applications in which the process, developed by The Mathieson Alkali Works, has thus far been found successful include removal of caustic after continuous jig scouring or mercerizing of open-width heavy fabrics, after warp yarn mercerizing, after kiering, and after caustic steaming.

PROTEIN CONCENTRATE

May be Used as an Ingredient in Animal Feed

IN TIME of protein shortage, high-protein concentrate can be obtained by means of alkali extraction from grass and used an an animal feed ingredient, according to an article in *Food Industries.*

"Of value as a concentrate for animals requiring low-fiber, high-protein diet may be the extraction of dried grass which, with sodium hydroxide solution and the neutralization of the resulting solution with acid, yields a precipitate containing a high concentration of protein, a considerable amount of carotene, and an insignificant amount of lignin and cellulose. Such a product is higher in protein than most protein concentrates, being exceeded only by those of animal origin. It is also higher than many animal feeds in carotene, a considerable part of the pigment in the grass having been absorbed by the protein precipitate," according to the article

"A ton of dried forage of mixed type grass taken from plots early in May should yield about 285 pounds of dried product. Further purification of the crude product, as far as protein concentration is concerned, may be obtained by extraction with alcohol. By this process the green coloring matter is removed and the resulting product is tasteless, though nearly black in color. It contains over 72 percent protein on the dry basis.

"The residual grass material may have some food value. It yielded in laboratory tests about 875 pounds a ton It is green in color and has the appearance of a palatable stock feed The alkaline treatment alone should not have affected it adversely since such treatment has been shown to increase the digestibility of straw," the magazine states

"Enormous quantities of protein-containing forage are unused annually by over-production during lush periods of growth, in discarded lawn clippings, and on ungrazed roadsides Surpluses may be restored to the soil for their fertility value as well as preserved in silage or hay, and there is also this possibility of converting the protein, which is the most expensive of the three major food constituents, into a less bulky and nonperishable form to supplement the diet of many animals"

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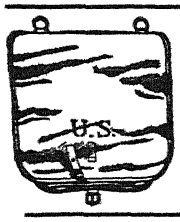

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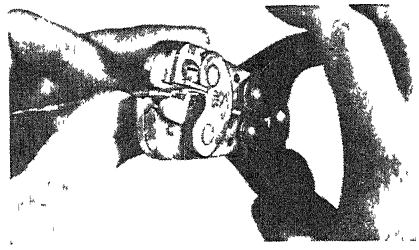
New Products

SOLDERLESS CONNECTORS

A TERMINAL connector for electrical wiring which has its insulation bonded to the terminal so that no insulation sleeving is required eliminates several tedious steps in making insulated electrical terminal connections. Developed by Aircraft-Marine Products, Inc, the connector eliminates the work of fitting and adjusting separate pieces of insulation sleeving over terminal connections

The insulated terminal incorporates another important advantage in that it



A simple crimping tool replaces the soldering iron on solderless lugs

also supplants conventional soldering methods. Press dies, or a simple hand tool resembling a pair of pliers, crimp the terminal connector and the wire it holds into a homogeneous mass, making a perfect electrical and mechanical connection

These solderless connectors are also available in uninsulated form. Where conditions require, they may be obtained in styles fabricated from corrosion-resisting metal

VACUUM-TUBE VOLT-METER

SPECIAL features of a new vacuum-tube volt-meter, made by Televiso Products, Inc., include high sensitivity, stabilized zero, and a built-in standard cell for calibration checks. Voltage ranges are .5-5-50-200 A C., full scale. It is accurate to 2 percent of full scale on voltage, 2 percent on frequency to 150 megacycles.

This new volt-meter has automatic zero adjustment on all ranges. Readings vary 1 percent with 10 percent line voltage fluctuation. It is used for RF-AF production and laboratory measurements by communications and electronic equipment manufacturers

HEATER REPAIR

BROKEN and burned out electrical electrical heating elements can be quickly and effectively repaired through the use of a new flux developed by the Chanite Sales Company. This flux, which incorporates a number of different natural materials, is applied to the broken element without special tools.

When a heating element has been burned out, it is necessary only to stretch the wire a bit so that the broken ends can be lightly joined, or to bridge the gap with another piece of wire, following which the wires are moistened with water applied with a piece of wood or a match stick The moistened stick is then used to apply a small amount of the flux to the joint and the current is turned on The flux instantly melts and forms a perfect bond between the ends of the wire.

It is claimed that joints thus made are as strong as the original wire and that any number of joints can be made in a heating element without affecting its utility. The flux is inexpensive and is used in extremely small quantities per joint.

COLD PADDING GLUE

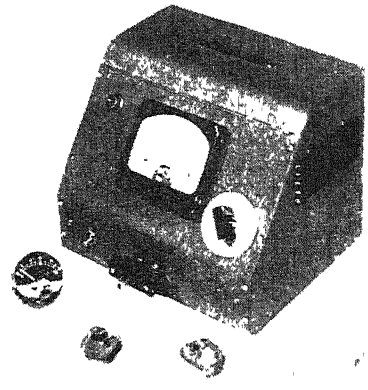
A SYNTHETIC resin-type cold padding glue, which is reported to successfully replace pre-war rubber latex compounds, is called Pliatab Available in red or white (natural) color, and in containers ranging from one quart to 55 gallons, it comes ready to use with a moistened brush or, diluted with water, in a spray gun This product, recently perfected by Paisley Products, Inc, serves equally well with all grades of papers, backing boards, and for many special gluing operations on cloth and leather bindings.

FLUXMETER

AS AN AID in production of radio and radar instruments, a new type electronic fluxmeter has been developed by J. Thos. Rhamstine The unit also may be used for checking and comparing the magnetic flux of any shape or type of permenent magnet

Designed primarily for checking the saturation of special Alnico meter magnets, this new device can be used for comparing various types of magnet steel. Different sizes and shapes of search coils may be used and may be small enough to insert in the air gap of assembled meters.

A direct reading indicating meter



Magnetic flux is read direct

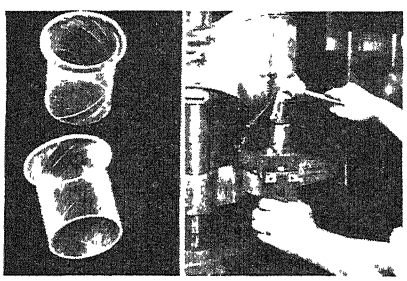
shows the flux as long as the search coil is in the magnetic field This new permeability comparator has no moving parts except for the indicating meter, and employs a special vacuum tube circut operating from the A C mains.

ACETATE GROMMETS

SPUN acetate grommets, produced by Precision Paper Tube Company, are revealing marked superiorities in aircraft, hydraulic controls, small motors, lamps—in fact, in the many purposes for which small grommets are used

Manufactured of acetate film, spirally wound and laminated for greatest strength, these grommets provide high insulating properties combined with the non-shatterable toughness of the material. Light weight, resistance to oil, moisture, and all climatic conditions are also advantages.

The main feature is the ease of assembly made possible by the method of manufacture. Grommets are supplied with one end spun, inserted in place, and subsequently spun over on stand-



Left: Acetate grommets ready for assembly and, right, rolling the grommets on a small standard drill press

ard drill press equipment with special tools supplied by Precision

The heat of the spinning operation actually shrinks the thermo-plastic material, so that a tight fitting, tough, permanent insulation results

PRECISION COUNTERSINK

TO FILL the need of precision countersinking of large rivets, bolts, and screws, the Aero Tool Company has developed a large-sized micrometer stop countersink. This new tool, which countersinks up to 1¼ inches, is capable of countersinking ½-inch rivets, and can be instantly and positively locked at each micrometer setting in increments of .001 inch. Adjustments are made manually and can be made while the tool is in operation.

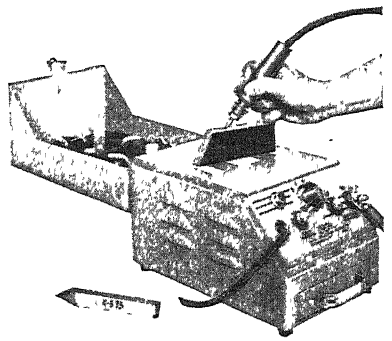
ETCHER AND DEMAGNETIZER

A NEW tool that is ready for instant use as either an etcher or demagnetizer, is enclosed in an attractive case with a removable, hinged cover.

To etch small tools and parts, they are placed on the work-plate, a switch is turned "On" to proper heat, the etching is started. A ground clamp is provided for etching parts too large for the work-plate.

A wide range of heats is provided for marking all iron, steel, and their alloys from small delicate parts up to large, smooth castings An indicating lamp glows brighter as each higher heat is used.

To demagnetize, it is necessary only to turn the switch "On" to either Num-



For etching or demagnetizing

ber 1 or Number 2 position and proceed as with an ordinary demagnetizer. Maximum rating is 5.5 amperes. Overall pole area, 13½ square inches

BRONZE-ON-STEEL

BRONZE faced pistons, which may well cause a small revolution in the manufacture of such parts, are made by a method which involves flame spraying of bronze on steel. The successful application of that method by the Neo Mold company's process (now proved under the most gruelling practical use) is the first of its kind, although attempts have been made in the past to achieve this particular result by other bronze-on-steel methods. Comparatively light steel blanks are sprayed with a special bronze alloy to a thickness of approximately .045 inch on the bearing surface This is rough machined in the initial production, then given the required high finish, with oil grooves

Pistons for aircraft landing struts were formerly machined from bronze castings Each required about seven pounds of bronze. Now made by the new process, some three and a half pounds of bronze are saved on each piston, and the finished product is lighter than the old pistons. Chief advantage is that the strength of steel is combined with the bearing qualities of bronze. Neo Mold metallurgists claim that the end-product is a bronze facing which for this application is superior to that of a machined bronze casting, one important factor being its oil bearing quality. Having a extremely fine porosity, the sprayed bronze absorbs and retains oil, becomes self-oiling.

This process is now being applied to all types of pistons for compressors and pumps, where a combination of strength, lightness, and wearing quality is essential

AIR STERILIZER

INDUSTRY can now safely apply a principle widely used in the hospital field—the germicidal effects of ultra-violet rays to the disinfection of the air—in plants and offices through the use of a new device known as Hygeaire System. This system is a combination of the well-known G.E Germicidal Tube and a patented reflector in

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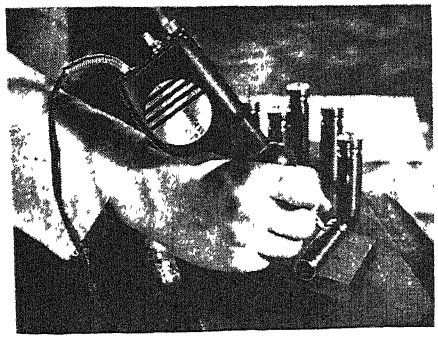

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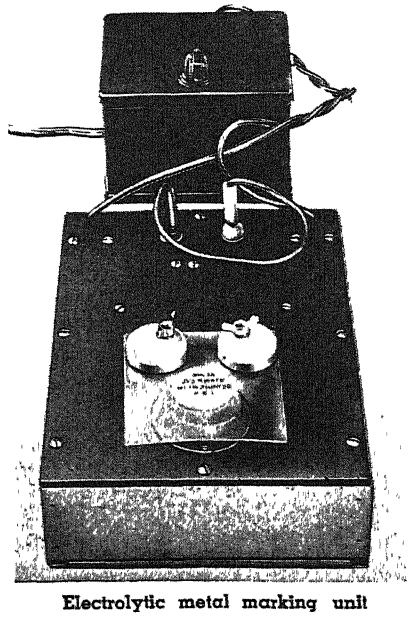
DIAMOND HAND HONE

DESIGNED with the diamonds set in a hard metal bond, a new hand hone provides an improved method for keeping cutting edges keen. Just a few strokes will quickly sharpen high-speed steel as well as the hardest grades of cemented carbide-tipped tools. It is claimed this hone holds its flat surface longer and will not score, groove, or chip.

METAL MARKING

YIELDING 1200 to 1500 impressions per hour, a new electrolytic method of marking metal is announced by the Acme Metal Marking Equipment Company. By means of Met-L-Etch, as the system is called, names, numbers, trade marks, inspection symbols, and other data are quickly and permanently etched on smooth metal surfaces without the use of acid. The part to be marked does not need any special preparation, nor does it require cleaning or neutralizing after being marked.

The operating procedure is simple. A drop of conductive solution, good for 500 impressions, is applied to a silver pad on which rests a celluloid stencil engraved with the mark to be etched. The part to be marked is placed on the stencil in contact with adjustable guide posts. The current is turned on by a slight pressure, one second being sufficient to produce a permanent mark that cannot be eradicated without removing the surface of the part itself.

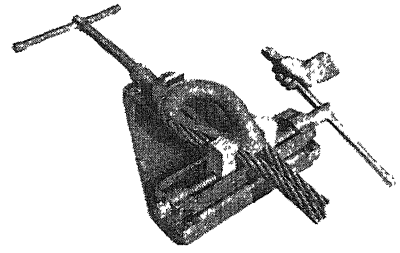


Electrolytic metal marking unit

Two models of Met-L-Etch are offered, one for marking flat surfaces, the other for marking the periphery of round parts

RIGGERS' FORMING VISE

FOR splicing and clamping wire rope and cable for forming around the thimble, or in forming slings, a new



Wire rope is held securely

rigger's vise has been announced by Patrick - McDermott and Company Known as the P-M Portable Riggers' Forming Vise, the unit is designed and built in such a manner that the shaft levers give complete and easy control of both front and back jaws. Wire rope or cable is securely held and formed in the vise, with guards to protect the threads from damage by and friction of the wire rope. Rigid construction assures great strength and durability

ELECTROPLATING COMPUTER

AN AID to the electroplater and plating chemist, made available by the Hanson-Van Winkle-Munning Company, is called the Jernstedt Electroplating Computer. It does for the plater what the slide rule accomplishes for the engineer—makes use of logarithmic scales to eliminate lengthy calculations Accuracy of control and a minimum loss of time are the results, after the plater becomes familiar with its operation.

Among other things, the instrument accomplishes the following: Computes chemical additions required in a plating bath of any gallonage. Indicates weight of metal deposited on unit area, given the thickness. Gives plating time required to deposit a given thickness of any metal. Computes current density required to produce a deposit of given thickness. Indicates thickness of deposit resulting from an established plating time at a known current.

PLASTICIZER SUBSTITUTE

SHORTAGE of the critical materials forming the usual plasticizers for cellulose acetate is being effectively relieved by PHO, a development of The Neville Company, according to a report from the company's research laboratory.

PHO can replace up to 50 percent of the usual expensive plasticizers for cellulose acetate. It is a viscous, resinous liquid, so that the total plasticizing oil content of PHO-made composition is somewhat higher than when the ordinary plasticizers are used alone.

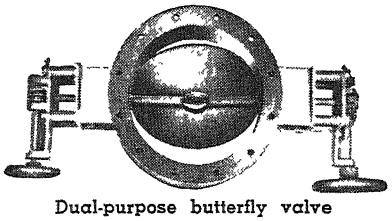
These plasticized compositions ar

being used as injection molding compounds for small industrial molded pieces, insulation parts, and for consumer articles such as pens, pencils, combs, and the like, and lacquers when dissolved in solvents

TWO-IN-ONE VALVE

DESIGNED for either a high pressure drop and small volume or a low pressure drop and large volume, a dual-purpose butterfly valve operates beyond the limitations of a single valve. Close control and shut-off of volume and pressure can be obtained and the valve is easily adapted to power operation

The larger beveled vane seats against the body of the valve while the smaller vane is free revolving Four to six revolutions of the hand wheel completely open or close either valve vane



Dual-purpose butterfly valve

This type of valve, developed by R-S Products Corporation, is available in various combinations of sizes and for operating pressures of 15 to 900 pounds per square inch

PROTECTIVE FILM

ANTI-CORROSION films for steel can be obtained by the use of Sublan, a product of the Glyco Products Company, Inc. Polished panels protected with a Sublan-mineral-oil mixture have been stored for 10 months and showed no rusting Furthermore, the film supresses latent finger prints on polished steel surfaces The film is readily removed by a cold solvent wash or dip.

FREQUENCY METER

FEATURES of a new direct-reading Norelco frequency meter include eight ranges covering 0-50,000 cycles and sufficient power to operate a strip-chart recorder without an auxiliary amplifier The instrument is of considerable value in research and development and for production, inspection, and maintenance applications

SAW-TOOTH GAGE

A CONVENIENT little gadget for lumber workers is a polished steel inserted-tooth saw gage, about 6½ inches long, by which the saw mill operator can check his filing job in order to obtain the best possible lumber

The gage, distributed by The American Saw Mill Machinery Company, is notched and marked so that one can instantly square the saw bits with the saw and see that each bit projects the same distance on each side of the saw, in order that each bit will do the same amount of work. It is important that each bit be checked on *both* sides of the saw, for only a little oversize by any bit on either side will mark the lumber and produce an inferior sawing job The gage will be sent gratis to any saw mill operator requesting it

FIRE FIGHTER

DESIGNED especially for fighting both flammable liquid fires and those of electrical origin, a new fire extinguisher ejects a stream of "All-Out" dry chemical which, when activated by heat, forms a dense, fire-smothering cloud over a flaming area up to 18 feet distant The insulating qualities of the cloud help guard against re-flash and create a heat-deflecting screen between the operator and flame, permitting close-range attack with greater safety and less heat discomfort The chemical, a non-conductor of electricity, is harmless to humans and to delicate, mechanized parts of motors or machinery

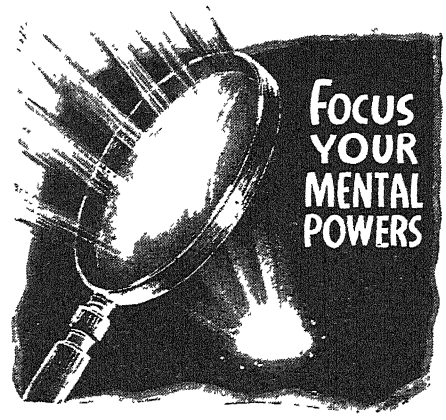
Weighing only 37 pounds fully charged, the "All-Out" extinguisher is easily maneuvered and can be quickly recharged at the scene of the fire

ALL-PLASTIC GOGGLE

JUST announced by Willson Products, Inc, is the new MonoGoggle designed to provide high impact strength, unobstructed vision, and the highest degree

Safety, comfort, unobstructed vision

of comfort. Weighing only 1¼ ounces, this new streamlined goggle has a replaceable, nonshatterable crystal-clear plastic lens and can be worn comfortably over any prescription glasses.



DO YOU THINK IN CIRCLES?

Do you ask yourself, "How shall I begin; what shall I do next?" Have you a confusion of ideas? Mastery in life, success in any enterprise, comes from the subtle ability to marshal your thoughts, to call to the fore, when an emergency arises, the proper mental powers. Mentally, you are an aggregate of forces. Why dissipate them because of lack of knowledge of how to properly use them? Learn to unite them, and you will have at your command, a *tremendous power* for accomplishment.

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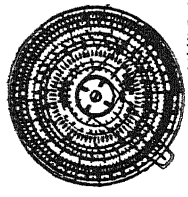

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Metals in Industry

(*Continued from page 21*)

Corps Specification An-A-17 with tensile strength of 32,000 pounds per square inch minimum, yield strength of 20 - 000 pounds per square inch minimum and a minimum elongation of 3 percent in 2 inches The properties of the cast alloy reach the foregoing specifications within three weeks at room temperature

Besides eliminating difficulties often associated with heat treating, development of the alloy has permitted the casting of large pieces that would otherwise require expensive heat treating equipment and the casting of high-strength aluminum in foundries that lack heat-treating facilities entirely

METAL TONNAGES

Compared for World War I and World War II

A study by WPB of the comparative annual rates of consumption of some 30 leading metals and minerals in this war, as compared with World War I, shows that magnesium stands at the top of the list with respect to percentage increase

Magnesium is used in this war at a rate 1400 times that of World War I. Aluminum is next with a current consumption rate 20 times as great Copper is being used at five times the rate and steel at about twice the rate of their consumption in the other war

In considering the figures for the light metals, impressive though they be, it should be noted that the *tonnage* increase for steel is far and away the largest. The country's steel production in 1918 was about 50 million tons, and in 1943 is was about 90 million tons—an increase of 40 million tons. Aluminum has gone from 50,000 tons to one million tons, and magnesium from about 200 tons to 300,000 tons.

Just the tonnage *increase* for steel actually dwarfs the present *total production* of all the other metals combined.

SHELL FORGING

Now Accomplished by Metal-Saving Process

Important production advantages have resulted from the adaptation by Porter-Blairsville Company, a division of H. K. Porter Company, Inc., of a new method of forging large caliber projectiles for the United States Navy.

Previously straight cavity forgings were used as raw material, the operations comprising upsetting and piercing, using a straight punch, in one pass in the press; drawing in a draw bench, using five rings; and machining to give the proper contour for nosing. Considerable metal was removed in machining the outside of the forging.

With the "contoured cavity" method now in use there is little waste of metal. A shaped punch is employed to make the contoured cavity, which flares out in size from the closed to the open end of the forging Since the required taper is produced by forging rather than by machining, the metal required per unit has been reduced approximately 13 percent

There are other advantages, the Porter-Blairsville Company reports Since the contoured cavity is of larger diameter, larger punches and mandrels are used, and these provide better rigidity and less wear in operation More concentric forgings and improved tool life result. There is also less tendency for the base to punch through in drawing

CARBIDE TIPS

Now Applied to Unused Tools

It has become common to salvage used cutting tools by brazing tungsten carbide tips to the used steel surface, but it is something new to reclaim unused tools as the Yale and Towne plant is now doing

In the early days of tipping, carbide tools proved so satisfactory that workmen were reluctant to use up the high-speed steel and carbon steel tools still in stock To cut down this dead inventory and to achieve some kind of early return from the investment in these tools it was decided to carbide tip all unused tools Now all unused tools are considered merely as blanks made for the individual jobs, that are placed in final working condition by tipping

NE STEELS

What is their Future in the Metals Field?

Few technical questions about the future loom as large in the minds of materials engineers and metallurgists as the probable position in the post-war era of the NE steels—the American wartime emergency steels, made in the open hearth, that have properties comparable to much higher alloy steels formerly used.

Edwin F Cone has made a survey of leading engineering opinion on this subject for *Metals and Alloys* and offers the following conclusions as a preview of the future of the NE steels:

As a class the NE steels are here to stay, although the extent of their use will be lower than at present Price factors as much as anything else will set the level of their ultimate use

The reasons for a lessened relative post-war demand will be (a) the fussier heat-treating behavior of the NE steels, (b) the psychology of favoring the familiar over the new or strange. (c) NE steel overpricing, so that either the lower prices of the "needled" carbon steels or the better properties of the higher alloy steels become more attractive, and (d) sales pressure from the alloy producers.

The older, high-alloy engineering steels will regain some (perhaps much) of the ground they lost during the war, but will probably not resume their former relative position.

Aviation

(Continued from page 9)

expansion by continuing construction of airports and airways on a large scale, by installation of blind landing facilities, and by general technical development.

Among other plans, the CAA is announcing the installation of automatic air traffic control systems in the Washington and New York areas These are to be ready for use in 1945 They are to be followed by similar installations in Los Angeles, Cincinnati, Cleveland, Chicago, and Oakland, California The position of aircraft will be reported and recorded automatically, and other devices will help in the work of traffic control

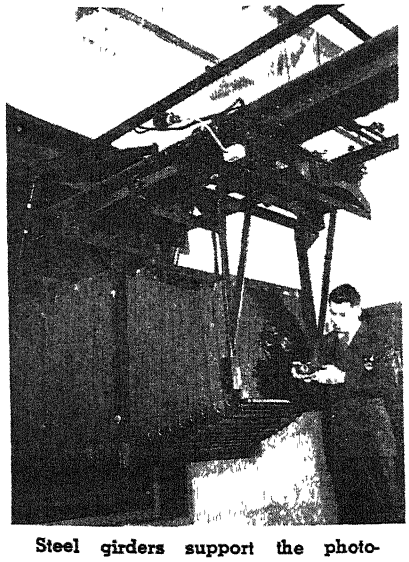
So congested may our airways become that it will be necessary to route traffic around major points in the manner used for controlling highway and railroad traffic.

PHOTO TEMPLATE

Process Speeded by New Change-Making Technique

LIKE DRESSMAKING, the building of an airplane requires a full-sized pattern —called a template—for each individual part, and in the Boeing Fortress, for example, there are 30,000 of these parts In former days, these templates were built laboriously by hand from conventional blueprints. Some were made of wood and some of steel, but in either case the work was slow, and many templates required as much as 200 hours of layout time. But with the photographic method of making templates, the process has speeded up immeasurably

The great saving in photo templates lies in the fact that hundreds of copies of a template can be made from one photographic negative. The original engineer's drawing or master layout is made to exact size in the engineering department on a sheet of thin steel. This master layout is then taken to the photo template darkroom for reproduction and is placed on a huge easel, to which the sheet is held tightly by vacuum The camera which does the job of photographing this master drawing is shown in one of our illustrations It weighs some six tons and is valued at approximately $20,000 The bellows and lens of the camera are in the same room with the easel, but the holder for the glass negative is in an adjoining room



Steel girders support the photo-template camera and connect it to easel, insuring complete rigidity

The master drawing is photographed on a glass negative about one fifth the size of the original drawing The camera which made the original negative is then used as an enlarger and the negative image is projected onto a sensitized steel sheet to the exact size of the piece to be reproduced

One of the original problems in speeding up work was developing a technique for changing some small detail without making an entirely new master template These changes are now printed on a translucent, dimensionally stable cloth substance, which is sensitized on one side The cloth print is then glued on the original template at the point where the change is to be made.

AREA AIRLINES

Designed to Supplement Major Routes

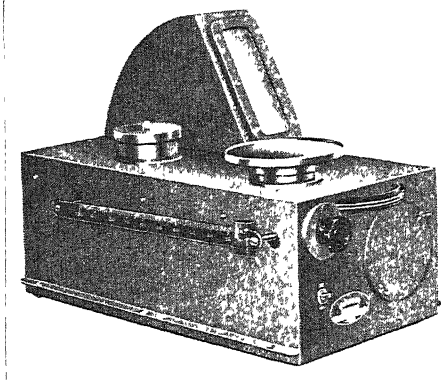
AN AMBITIOUS yet sensible plan whereby the benefits of scheduled air service can be extended to more local areas has been put forth by Southwest Airways. Called "Area (Feeder) Airlines," the system is described in the following words

"They are lines that would serve within untapped, potentially rich trade areas, feeder systems that would supplement trunk (major) airlines, carrying passengers, mail, and express over small city and rural routes radiating outward from central air terminals Operating smaller airliners, they would bring speedy, reliable, and frequent schedules to thousands of communities now untouched by air service—and where there are no landing facilities they would still pick up and deliver airmail and cargo through the use of a special mechanical device, so that rural districts as well as metropolitan centers would have direct air service"

The equipment which would be employed on area airlines includes twin-engine transports designed to accommodate 10 to 12 passengers and to carry 800 to 1000 pounds of mail and express Cruising speed would be approximately 180 miles an hour to assure a scheduled speed of 120 miles an hour with full allowance for time spent in climbing into the air, maneuvering, and descent Stations would be only 15 to 20 miles apart, which would constitute a decided element of safety. Helicopters might be used in certain areas. The operators would be new companies—not those already interested in the great transcontinental airways, but relatively small though stable concerns which understand the needs of certain regions and are willing to devote themselves wholeheartedly to the service of those regions.

Exact Weight Scales

Now Handle Tare by ELECTRONICS



In the past tare compensation has been handled entirely mechanically with sliding tare poise, motor driven tare poise, adjustable dial or chain loading of lever. Now for the first time this vital operation, so important to unquestioned accuracy, is governed by electronics, through an ideal union of mechanical and electrical principles. Rotation of the control knob through 270 degrees compensates for variations in container weight within reasonable range from a few grains to several pounds. The new Electronic Tare Compensator is standard equipment in the EXACT WEIGHT Electrograph Scale but is obtainable for all EXACT WEIGHT Scales on special order. Write for details covering this revolutionary new development.

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Current Bulletin Briefs

Conducted by K M CANAVAN

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

A TABLE OF COMMON HAZARDOUS CHEMICALS is a 32-page compilation giving information designed to promote and improve methods of fire protection and prevention in plants where hazardous chemicals must be employed *National Fire Protection Association, 60 Batterymarch Street, Boston 10, Massachusetts —30 cents*

THE USE OF SULPHUR IN THE CONTROL OF TRUCK CROP AND CANE FRUIT INSECTS AND DISEASES is an 86-page booklet describing the insects and their effect on a list of over 50 crops and fruits, and outlining the proper control uses of sulphur in each case *Texas Gulf Sulphur Company, Second National Bank Building, Houston 2, Texas —Gratis*

A PROPOSED WORLD GOVERNMENT, by George A. Birdsall, is a 110-page booklet briefly outlining the author's plan, its possible effect on the nations, and the philosophy of world government. A Constitution to provide World Government is set forth, containing 10 Articles *George A Birdsall, 301 South Highland Street, Arlington, Virginia — $1.50*

LARCO DIAMOND TOOLS is a 32-page booklet covering the most pertinent facts about grinding wheels in question and answer form. Also given are cross-sectional views, sizes, and prices of various models. *Plant Service Department, Larco Tools, 551 Fifth Avenue, New York 17, New York —Gratis Request this on your business letterhead.*

ALUMINUM IMAGINEERING NOTEBOOK is a survey of 12 important economic advantages of aluminum plus some examples of things that have become realities. *Aluminum News-Letter, 2195 Gulf Building, Pittsburgh 19, Pennsylvania —Gratis.*

GEON RESINS AND PLASTICS is a four-page folder which outlines the characteristics and specific properties of four Geon resins and also the characteristics of Geon plastics. A partial list of their applications is also presented. *Chemical Division, B F. Goodrich Company, Akron, Ohio —Gratis*

AN IMPORTANT MESSAGE FOR ALL USERS OF INDUSTRIAL TAPES is a six-page manual giving suggestions for the proper selection, handling. use, and storage of industrial adhesive tapes. Individual sheets are devoted to information for department heads, employees using tapes, and storeroom personnel These sheets are detachable for posting on bulletin boards. *Bauer and Black, Industrial Tape Division 2500 South Dearborn Street, Chicago 16, Illinois —Gratis Request this manual on your business letterhead*

FACTS ABOUT COLOVOLT—THE NEW COLD CATHODE LOW VOLTAGE LAMP is an eight-page booklet containing complete data and a listing of 40 features of this fluorescent lamp, including instantaneous starting, wide voltage range, reduced fire hazard, and a one-year operating guarantee *Mr R L Sullivan, General Luminescent Corporation, 638 South Federal Street, Chicago 5, Illinois —Gratis Request this booklet on your business letterhead*

JEWELS OF INDUSTRY is an illustrated folder outlining the significance of Eli Whitney's idea of interchangeability which resulted in mass production based on precision measurement Also presented is the importance of quality control of production *Continental Machines, Inc , 1301 Washington Avenue, South, Minneapolis 4, Minnesota —Gratis*

LIQUID VIBRATING SCREENS is an eight-page illustrated booklet covering the installation, construction details, dimensions, and weights of screens for recovering many types of waste products and reducing pollution *Link-Belt Company, 307 North Michigan Avenue, Chicago, Illinois.—Gratis*

CANNON PLUGS FOR AIRCRAFT BATTERIES, ENGINES AND GENERAL APPLICATIONS is a 24-page bulletin with illustrations, sectional views, and data sheets on a variety of battery connectors Also presented is a summary of the uses, styles, and features of all the types of connectors. *Catalog Department, Cannon Electric Development Company, 3209 Humboldt Street, Los Angeles 31, California —Gratis*

ECONOMY BOILER BAFFLES is an illustrated bulletin showing how fuel economy and greater steam generating capacity can be achieved by the modernization and proper location of baffles. *The Ramtite Company, Division of The S Obermayer Company, 2563 West 18th Street, Chicago 8, Illinois — Gratis*

CHERRY BLIND RIVETS is a 36-page manual describing and illustrating drilling the hole, selection of the rivet, operation, installation procedure, tools, and inspection technique. Request Manual B-44 *Cherry Rivet Company, 231 Winston Street, Los Angeles 13, California.—Gratis.*

SIMMONDS PRODUCTS FLY WITH FAMOUS PLANES is an eight-page illustrated booklet describing a group of advanced aircraft and industrial products—an automatic engine control, precision push-pull control, hydraulic fuse, and chronometric radiosonde. Post-war plans of the company are outlined. *Simmonds Aerocessories, Inc., 30 Rockefeller Plaza, New York 20, New York.— Gratis.*

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By Wallace E. Pratt

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PROPOSALS for several interesting varieties of modified Gregorian telescopes, offered to other advanced members of the amateur telescope making fraternity by Lyle T. Johnson, Box 236, La Plata, Md, are contained in the following extracts and abstracts from several of his letters

"As I was reading Pickering's chapter, 'Reflectors versus Refractors,' in 'A.T.M.A.,' his statement, page 607, about the extensive diffraction effects due to the large size of the secondary mirrors in Cassegrain and Gregorian telescopes, led me to wonder whether some way couldn't be found to reduce these effects. I have figured out two ways of doing this for the Gregorian telescope In the best of these (Figure 1) the small mirror is placed at the focal point of the primary, and its diameter is equal to that of the field desired at the eyepiece divided by the amplifying power of the secondary

"In the layout shown the elliptical flat (½" minor axis) will give a field of 2" diameter at the eyepiece The cone of light (from a single star), reflected from the secondary to the eyepiece, has a diameter at the flat of 3", or six times the diameter of the flat. This means that the small flat will give the same diffraction effects and light obstruction as a 2" mirror in front of the 12" primary. I will call the diameter of this imaginary 2" mirror the 'equivalent diameter' of the flat As the secondary mirror of the conventional 12" Gregorian would be 3½" or 4" in diameter, the modified Gregorian should give considerably better definition.

"As the secondary of the modified Gregorian is not in front of the primary mirror, it may be made as large as desired. That is, since there is no necessity of cutting the mirror to exact size, Pyrex blanks can be used just as they come. Also, turned edge would do no harm, whereas a slight turned edge on a conventional Cass or Greg is disastrous to definition.

"No perforation of the primary is necessary. Because the light beam doesn't have to pass through the hole, correct design would make a larger field available for photography.

"This telescope would have a rather unconventional tube—L- or T-shaped and wider than it is long It probably would be possible, however, to design a mounting with the light passing from the secondary through a hollow declination axis to the eyepiece at an easily accessible point

"In the conventional Gregorian the minimum value of amplification of the secondary is about 5, but in the modified type it could be made smaller if desired.

"Although the diagonal flat is extremely small, the more advanced amateurs probably wouldn't have too much difficulty with its construction

"As the eyepiece is at one focus of the ellipsoidal secondary, and the small flat at the other focus, any dust on the surface of the flat would be sharply in focus at the eyepiece. This bad effect might be reduced or eliminated by moving the flat a little farther away from the primary. This would cut down the diameter of the field of view, unless the flat were made larger—which in turn would increase the diffraction effects and light loss The flat probably could be shifted far enough from the primary focus to throw the specks of dust out of focus without reducing the field of view too much.

"As the two beams of light cross at the position of the flat, the construction of the diagonal supports is more complicated than in the Newtonian.

"An alternative method of reducing the diameter of the obstructing mirror, which was considered, required a larger flat placed between the primary and its focus. This would reflect the light from the primary to the secondary at the side of the tube, and then back through the hole in the primary to the eyepiece It, however, was seen to give only a slight reduction in the diameter of the central obstruction, hence not much would be gained It also has the disadvantage of four reflections instead of three, and the primary must be perforated.

"The modified Greg eliminates one of the disadvantages of many Gregorians—direct light from the sky striking the eyepiece.

"Design data

"Primary, 12" $f/3$.

"Secondary, 5" or 6" diameter

"Equivalent focal length, 144"

"Diameter, d, of secondary necessary for rays parallel to axis is given by $d/12 = 12/36$, therefore $d = 4$"

'Diameter, D, of cone of light reflected from 4" secondary is given by $D/36 = d/48$, or 3"

"If equivalent diameter of flat is E, and primary mirror diameter is M, then $E/M = ½/D$ and $E = M/2D$, or 2"

'Useful diameter of field at secondary focus = ½" times amplification, or 2".

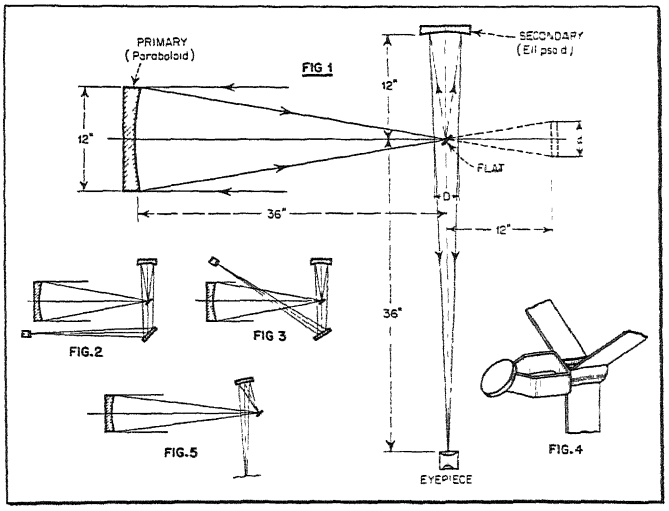
"This idea of mine may not be new

"If the mounting for the modified Gregorian should prove too difficult it would be possible to make the tube more like that of the conventional telescope, at the expense of an extra reflection (Figures 2 and 3)

"Figure 4 shows the small diagonal support, which presents a minimum of obstruction to the light traveling from the concave secondary to the eyepiece. If the obstruction of light before it gets to the primary is greater than the diameter of the flat, this makes no difference as long as it is smaller than the 'equivalent diameter' of the flat Thus, in Figure 1, the obstruction at the center of the spider could be up to 2" in diameter without obstructing more light than the flat does.

"Later, while 'pushing glass,' I thought of another modification (Figure 5) which further reduces the bad effects due to the diffraction around the secondary Its secondary is an off-axis ellipsoid The beam of light misses the diagonal entirely. Obstruction by the small diagonal occurs only before the light reaches the primary and, if the diagonal has a diameter of a half inch or so, the obstruction is insignificant. In fact, the diffraction due to the spider would be more serious than that due to the diagonal itself. This telescope should approach the performance of a refractor of equal aperture, more closely than any other type of reflector

"Another advantage of this general type of Gregorian [shall it be called the crossed, or Johnson, type?—*Ed.*] is that there is a certain amount of interchangeability of the secondaries, so that one off-axis ellipsoid could be used as the secondary for almost any paraboloid of approximately a given diameter. On the contrary, the secondary of the conventional Cassegrain or



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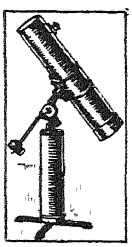

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Gregorian must be made especially for that particular diameter and focal length of primary This quality could be made use of by a person who desired to build a second Gregorian a few inches larger than the first

"Figuring an 'off-axis' ellipsoid would be difficult—just how difficult I don't know The fellows who have been designing [Schell —*Ed.*] and making [Beede of Youngstown, Ohio —*Ed.*] off-axis paraboloids could perhaps shed a little light on the subject It perhaps would be best to figure the mirror spherical and then arrange the pinhole, mirror and knife-edge in the same positions as the primary focus which mirror and eyepiece would occupy in the telescope Then one could see what the mirror looked like, and figure accordingly If things permit, I may make one of these telescopes but, if you publish this, someone else may come up with some better ideas on the subject in the meantime"

Johnson's letters were shown to Porter, who commented "That's the way —try it out and find the bugs in it, if any"

Johnson next performed an experiment to throw light on figuring the off-axis ellipsoid (Figure 5) with small polishers but the equations pertaining to it would be too detailed to publish here Especially interested readers may borrow them, or should write to Johnson direct.

All of Johnson's data were next submitted to Norbert J Schell, 1019 Third Avenue, Beaver Falls, Pennsylvania, one of the amateur group (Beaver County Amateur Astronomers Association) 25 miles north-west of Pittsburgh, near Ohio's border Schell is the originator of the off-side, or unobstructed, reflector (this column, April, 1939), also of the off-axis reflector (May, 1940) and is a widely known advanced amateur designer His invited opinions, comments.

"So far as I know, this is a new way of getting away from most of the obstruction in a compound reflector The only other similar effort to reduce the effective size of the obstruction was that mentioned by Dall, ('A T M A,' page 584)

"Johnson's method is sufficiently different, using a Gregorian set-up and all reflecting surfaces, to give him credit for doping out something new

"Of his designs I rather prefer the on-axis type as being somewhat more fool-proof, but the off-axis type would, or rather could, be made to get away from the somewhat awkward arrangement of the on-axis.

"The off-axis type, like all other off-axis arrangements, would result in a restricted field, as the field will be the same as the field resulting from the use of the larger imaginary surface, a side section of which is represented by the off-axis surface in use.

"The off-axis type could be designed with the secondary closer to the small flat than with the on-axis, and in this way would bring the secondary focal plane closer to the tube.

"It seems to me that, since the off-axis design leaves only the obstruction of the small flat it might be better with it to make the primary an *f* 5 or even *f*/6, which would still leave a flat rather small—say an inch or so—and reduce the amplification factor of the secondary accordingly. This, with moving the secondary closer to the flat. would make it possible to bring the secondary focal plane about a foot or so outside the tube

"There is another reason why I would suggest that the secondary be small It would not be necessary to make and figure it as a section, but it could quite easily be made full size of the imaginary secondary, and thus figured symmetrically in the regular way This large secondary would, in use, be placed so that the proper off-axis part of it came into action I would recommend this method over either making the section only, or making several sections en-bloc I have tried both and I am satisfied that by this method, surface accuracy is more readily obtained and this is well worth the use of the over-sized surface I would not recommend this for very large surfaces. or for off-axis primaries as such. but for secondaries, by all means.

"As to the efficiency of Johnson's Gregorian, I think it should work out in the regular off-axis form at least as well as a first-class Newtonian with small flat, such as is used for higher powers; and in the off-axis form, I think it will surprise those who have had no previous experience with reflectors working with little or no central obstruction

"There is another angle to the off-axis form, which may be found to be an improvement To wit Obstructions are usually out in front of the primary almost as far as the focus, and the resulting diffraction is without question worse than if there were a similar size of obstruction at the mirror surface (or at or near an object glass) In Dall's experiment to bring out effects of various sized obstructions, from which he came to the conclusion that a 1/5-sized obstruction is as large as could be used without causing too much trouble, I don't think he brought this double distance into effect. At least he did not displace the obstruction relative to the diaphragms used In this on-axis Gregorian of Johnson's the effective obstruction is only ¾ the distance from the focal plane to the secondary—a much shorter path for diffraction to spread out. This might be found to produce only the diffraction effect of a considerably smaller obstruction at the usual location This is one of the reasons I prefer the on-axis design in this case—the other being the matter of field, previously mentioned

"The job of figuring an *f*/3 primary must also be given consideration.

"Some trouble must be expected from maintaining good smooth coatings on the small flat—and of course this must be a really good flat.

"I hope you will mention Dall in this, as his scheme, referred to above, always stuck in my mind as a starter toward the ideal way of reducing the obstruction of a symmetrical. or on-axis, mirror."

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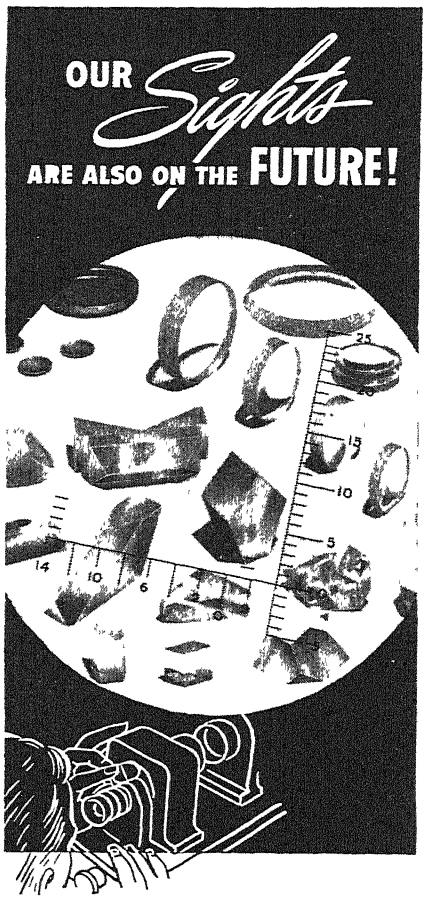

The demands of our Armed Forces still hold top priority on Univis production schedules for precision instrument lenses and prisms. But we have raised our sights above the needs of war to focus them more clearly on the industrial needs of the future.

In the coming battle for markets that will mark the resumption of peacetime production, *quality control* in the manufacture of products will play a major role. And precision instruments involving lenses and prisms are vital to such quality control.

We shall welcome the opportunity to discuss with you and to assist in the development of your post-war products which require the use of precision lenses and prisms.

PRECISION
IS A HABIT WITH
UNIVIS

INSTRUMENT LENS DIVISION
THE UNIVIS LENS COMPANY
DAYTON 1, OHIO
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Previews of the Industrial Horizon

By A. P. Peck

UP WHERE THE AIR IS THIN

RESEARCH in connection with high-altitude airplanes, such as the B-29 Superfortress that already has proved its military prowess in the Pacific theater, is going to contribute much to the comfort of the air traveler of tomorrow. For many months Boeing has delved into the mysteries of what happens when men and materials are subjected to the low atmospheric pressures and low temperatures of the stratosphere. That they have come up with many of the right answers is evidenced by the success of the B-29 That these same answers will influence the design of tomorrow's air transports is equally evident

Advantages of stratosphere flying are well known high speed, freedom from storms, and so on. Equally well known are some of the disadvantages, but the methods of overcoming these drawbacks are not so obvious Passenger comfort and safety are foremost desiderata of commercial airlines The same is true in military bombers The men who have developed the designs which today are bringing our bombing crews back safely from successful missions are the men who are laying the groundwork for the luxury airliners of the future.

Don't look tomorrow for nightmarish super planes that will carry you to London in a matter of minutes, but do look to designs such as the Superfortress for a glimpse of what the airplane industry will be using for your convenience when you can once more step up to a ticket office and buy accommodations on a plane leaving that same day!

PUBLIC RELATIONS

PROGRESSIVE managements are today paying far more attention to the serious subject of public relations than ever in the past. Whether making consumer goods or producing capital goods, these managements are finding that the more the public knows about their operations, the more successful their organizations become The day of the light under a bushel is past and the tale of the unadvertised mousetrap has been proved fallacious. Find a corporation that has done a conscientious job of public relations and you will find a corporation that has the confidence and understanding of the man in the street. And, at the same time, you will find a successful business organization

FROM ENGINE TO WHEELS

FOR A WHILE prior to the war, some manufacturers were adapting hydraulic transmissions to motor vehicles, eliminating the conventional gear trains and their attendant mechanical difficulties. These same methods of coupling power plant to driving wheels have been extensively applied to military vehicles with the inevitable result they have been highly refined. Now engineers predict that motor vehicles already dimly discernible on the public's horizon (but don't look for them the day after Tojo and Hitler fold up) will be equipped with hydraulic couplings and transmissions that well set new standards of automatic operation with the elimination of the friction clutch and with new extremes of smooth operation and long service.

MECHANICAL RUBBER GOODS

INDUSTRY in general is becoming more and more conscious of the need for vibration absorption, noise suppression, and shock absorption in machinery. A machine that sets up excessive vibration, that is noisy in operation, that transmits impacts from one part to another or from itself to its surroundings, is an inefficient machine It is wasting power and is building up within itself an early one-way trip to the scrap pile. Fortunately, research engineers recognize this simple truth and are doing something about it. For example, General Tire and Rubber Company is concentrating on applications of rubber to machine bearings, mountings, couplings, and gear bushings to eliminate those by-product mechanical forces which spell destruction to machinery This is a phase of research engineering that is going to mean much to industry and consumer alike

PICTURES FROM THE AIR

TO BRING John Q Public into the industrial picture for a few more minutes, let's take another look at television. Still a problem-child to many, the romance of pictures from the air has undoubtedly caught the public fancy. If you doubt that John and his family are sold on the idea of television, you have only to look at a recent report made by the Franklin Square (Long Island) National Bank. That institution has inaugurated a unique savings plan in which deposits are earmarked for specific post-war product purchases.

Some 22 percent of the depositors state that they are saving for television receivers, with only 13 percent speaking up for new motor cars! And 5 percent of them are thinking in terms of helicopters!

What the public wants the public usually gets. And the television market that is just over the horizon is going to surprise many conservative people who, mentally and whether they will admit it or not, are still in the hoss-and-buggy era

INDUSTRIAL RESEARCH

WE CANNOT resist the temptation to quote briefly here from recent statements by Sir Harold Hartley, Vice President of the London, Midland and Scottish Railway Company

"The prosperity of Britain after the war," said Sir Harold, "will depend more than ever upon the efficiency and progressiveness of our industries . This formidable task can only be achieved by using to the full our inventiveness and technical skill both to increase the efficiency of our older industries and to develop new commodities which will hold their own in the markets of the world. . . Only research can refashion existing industries effectively and create new ones. . . Labour and research must work hand in hand"

FOR FUTURE REFERENCE

TERRORS of the dentist's chair are reduced by the use of chrome-finished drill burrs. By their sharpness they reduce considerably the time required for cavity preparation. . . The extent of that much-talked-about post-war motor-car market is indicated by the fact that nearly 4,000,000 motor vehicles went out of service in 1942 and 1943 and have not been replaced. . . Cereals disguised as candy bars are the latest idea of the food industry, determined to make us eat cereals whether we want to or not. . . Indicative of some of the things that plastics can do is the fact that they have saved seven pounds of weight in magnetic compasses used by tanks and armored vehicles. . . Aircraft power-plant manufacturers have an eye on post-war markets in the field of ground vehicles of all sizes and shapes. They also can teach automotive engineers much about power/weight ratios.

AGAIN, ZENITH MAKES HEARING AID HISTORY!

Brings New Smartness and Style at No Extra Cost with the

New Neutral-Color Earphone and Cord

ZENITH made hearing aid history by bringing fine precision *quality* within reach of all Now Zenith follows through—makes history again—brings you, in its complete production, an entirely new standard of hearing aid *smartness and style!*

With the exclusive New Zenith Neutral-Color Earphone and Cord—developed after years of research—Zenith now does for the hearing aid what modern styling did for eyeglasses! Now America's hard of hearing can wear an aid with visible parts that are *scarcely noticeable,* because they blend with any complexion Best of all, they are available to present purchasers at no extra cost—*included* at Zenith's history-making low price of $40!

With this smart new Zenith ensemble, even the most sensitive wearer can feel perfectly poised. For it brings an attractive new "look of youth" to the hearing aid You'll notice it immediately when you look at yourself in the mirror. Now, no one need feel self-conscious about wearing a hearing aid.

See the proof of this today. And *hear* the proof of excellence in performance that has made America swing *overwhelmingly* to the New Zenith Radionic Hearing Aid. Visit the Zenith-franchised dispenser nearest you. Or, for complete information by mail, use the convenient coupon below.

THE NEW EARPHONE

- Smart, modern, scarcely noticeable! Pleasingly neutral in color so that it blends with any complexion
- Sturdily constructed of beautiful, long-wearing plastic.
- Comfortable to wear because it's feather-light in weight.

THE NEW CORD

- Made of translucent plastic—looks well with any apparel Friction or clothing noise is less than with any of the old-fashioned fabric-covered cords.
- Slender, light in weight, infinitely smarter and more comfortable to wear. And it lasts longer
- Perspiration-proof . . . water-proof . . . kink-proof . . washable Will not fray, wipes clean with damp cloth.

THE NEW ZENITH RADIONIC HEARING AID

Accepted by American Medical Association Council on Physical Therapy

★

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With New Neutral-Color Earphone and Cord . . . Crystal Microphone . . . Radionic Tubes . . Batteries . . . One Quality, Zenith's Best.

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GOOD NEWS FOR CANADIANS

The New Zenith Radionic Hearing Aid is now available in Canada—*direct by mail only*—at $40 complete (Canadian currency) with no additional charge for transportation, duties, taxes! For details write our Canadian distributor, Dept. SA-8, Zenith Radio Corp of Canada, Ltd ,Guaranty Trust Bldg ,Windsor,Ont

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P. O Box 6940A, Chicago 1, Illinois

Please send me your Free descriptive booklet on the New Zenith Radionic Hearing Aid.

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ZENITH RADIO CORPORATION, CHICAGO, ILLINOIS

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of August, 1894)

AUTOMATIC PHONE — "The Mutual Automatic Telephone Company . . has an invention which is designed to obviate the annoyance and difficulty attending the obtaining of connection with other parties through the operations of a central office, as under the present system With the automatic system a small keyboard, containing four keys, marked respectively 'hundreds,' 'tens,' 'units' and 'release,' is attached to each telephone These the subscriber manipulates when calling up a correspondent. For example, if he should want '122' he would press the key marked 'hundreds' once, 'tens' twice, and 'units' twice, and then ring the bell. When through with the conversation he will press the next button, which is the 'release.' "

ARTIFICIAL SILK — "In the process of producing 'artificial silk,' invented by Dr. Lehner, waste cotton, wool, jute, or other suitable material is reduced to an emulsion by means of a mixture of nitric and sulphuric acids, when it is formed into threads by forcing it through glass tubes of small bore, and is passed over a series of rollers and wound in the ordinary way on bobbins Before the artificial silk is used in manufacture, or is sold, it is denitrated to destroy the explosive properties, and is also rendered uninflammable, which will render it suitable for many purposes, especially as it is said to resemble real silk very closely"

FLYING MACHINE — "Fools may laugh at a man who devotes whole years of his life and many thousands of pounds to constructing a flying machine which runs on rails, but it has been said of old, he laughs best who laughs last There can be small doubt that Mr. Maxim holds in the palm of his hand a contrivance which little more is required to make perfect for aerial flight."

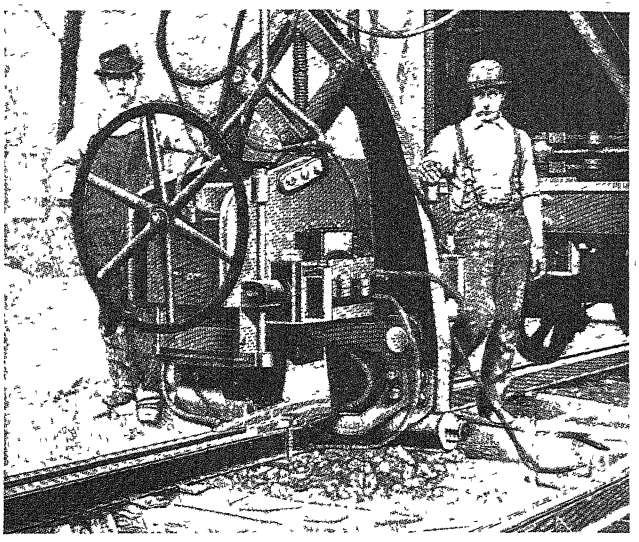
UNBALANCED LOCOMOTIVES — 'For the past ten years, and possibly longer, there have been practical evidences, upon certain railroad lines upon which speeds of 70 miles an hour and over are attained, that imperfectly balanced engines are great track destroyers, and that in extreme cases they make a permanent bend in the rails. . With the increased demand for high speeds, locomotives will have to be designed that are perfectly balanced. The limit of safe speed with unbalanced engines has been reached and passed"

METAL STRENGTH — "When the earth shall have cooled until the air is condensed as a liquid sea above the land and the frozen oceans, the non-crystalline metals, as Professor Dewar has shown in one of his latest lectures, will be much stronger than they are now. Small bars of the metals, cooled by liquid oxygen or air, were stretched in a cement-testing machine until they broke with the strain. At about 290° below zero Fahrenheit, the breaking strain of copper, which is 22 3 tons per square inch at ordinary temperatures, was increased to 30 tons"

MERCHANT MARINE — "The necessity for the immediate encouragement for the building, by American citizens, of a fleet of ocean steamships, capable to the highest speed, and constructed with special reference to government naval service, in case of war, led the Congress of the United States to enact certain special laws upon the subject."

FERRY TRAFFIC — "It is estimated that the yearly passenger trips on ferryboats between New Jersey and New York number 70,000,000; that the total for all New York ferries will exceed 170,000 000, that the number of boat trips equals 1,800,000, and the number of teams carried 5,000,000 This immense traffic is carried on with remarkable safety"

WELDED RAILS — "On the advent of the electric welding, a very obvious application of it seemed to lie in the welding of rail joints. . . The electric street car companies have shown a disposition to adopt welded joints, not only to secure a continuity of track for mechanical reasons, but for electrical ones also As the track is used for the return current, it is



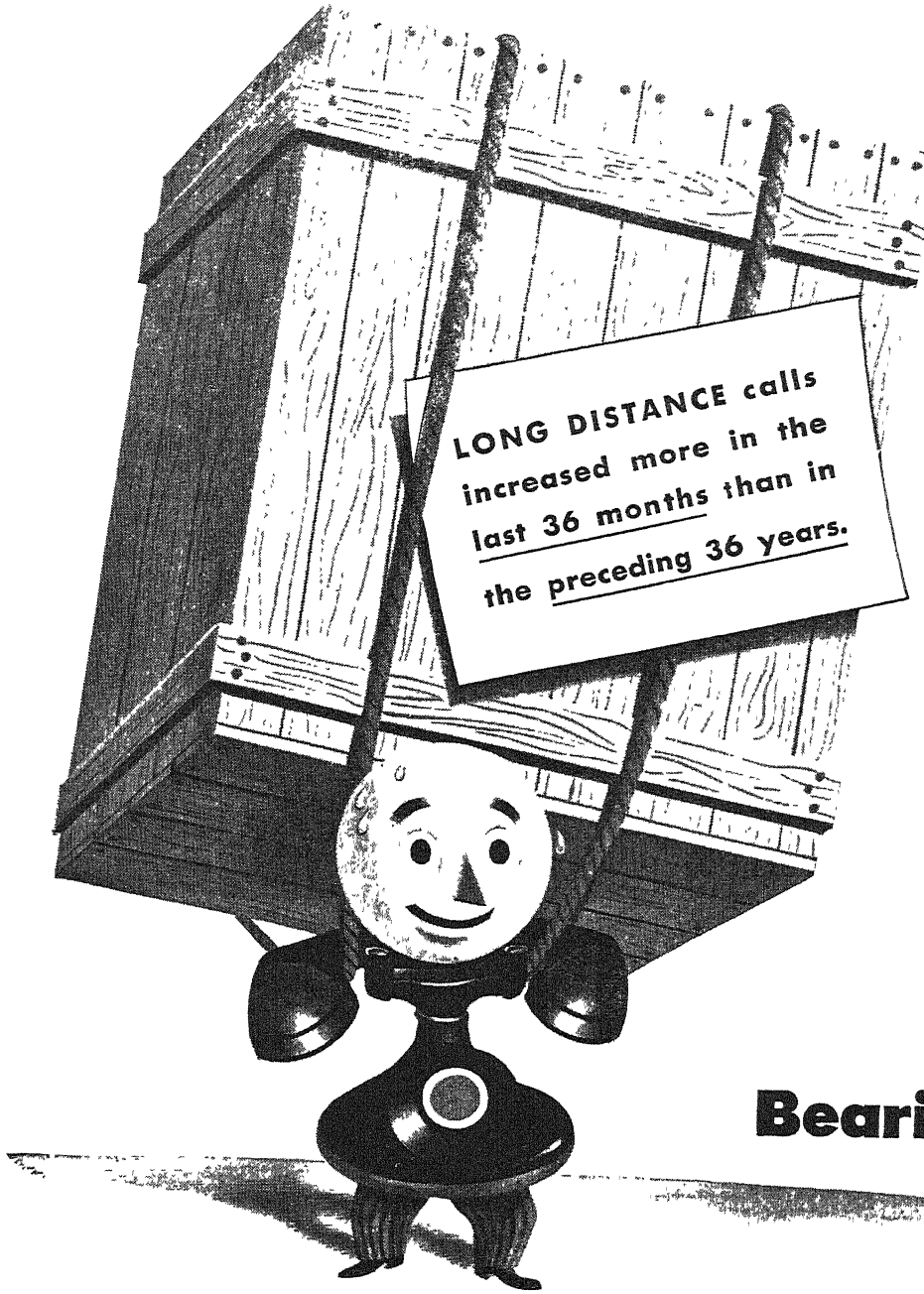
obvious that its conductivity should be as high as possible, and such conductivity is evidently favored by welding the joints together. We illustrate one form of the welding machine . . . which consists of a Thomson welding machine of special construction arranged to be carried on a crane projecting from a construction car. . . The operation is so perfect that after the welding is done and the ground is filled to its level, it is almost impossible to tell where the weld has been completed."

FRUIT SUGAR — "A recent chemical discovery which will be of great practical interest in those portions of the United States where the preservation of fruits has become an established industry is a process by which fruit sugar may be manufactured from beet juice. . It consists in the inversion of beet sugar at a certain stage of its manufacture by chemical treatment into what is technically designated 'laculose,' which is chemically identical with the natural fruit sugar."

PROPELLER — "The introduction of the screw propeller into use was accomplished simultaneously by Smith in England and Ericsson in the United States Both were men of great ability. Each considered himself the inventor of the screw propeller . . Each introduced the screw propeller on war vessels in 1843, Ericsson on the Princeton and Smith on the Rattler."

STORAGE BATTERIES — "Occasionally we read predictions of the possibilities of the coming storage battery Much of the misconception in regard to the power of the storage battery must be ascribed to the sensational manner in which it was introduced to the public by a very great scientist, his statement in regard to holding 'one million foot-pounds of energy' in his hand not yet having lost its effect. The great value of the storage battery in its proper field, which is of vast extent, and as yet scarcely entered in this country, should be sufficient to satisfy its most sanguine friends. Only harm can come from making claims beyond its power to fulfill, and much harm in this way has been done."

BICYCLES — "The sum of 100.000 marks is included in the German army estimates for the present year for the supply of bicycles to the infantry. . . Bicycles are to be used for communications between columns on the march and for communications between advanced guards When troops are in quarters, bicyclists are to fulfill the functions of orderlies, especially where mounted orderlies are wanting"

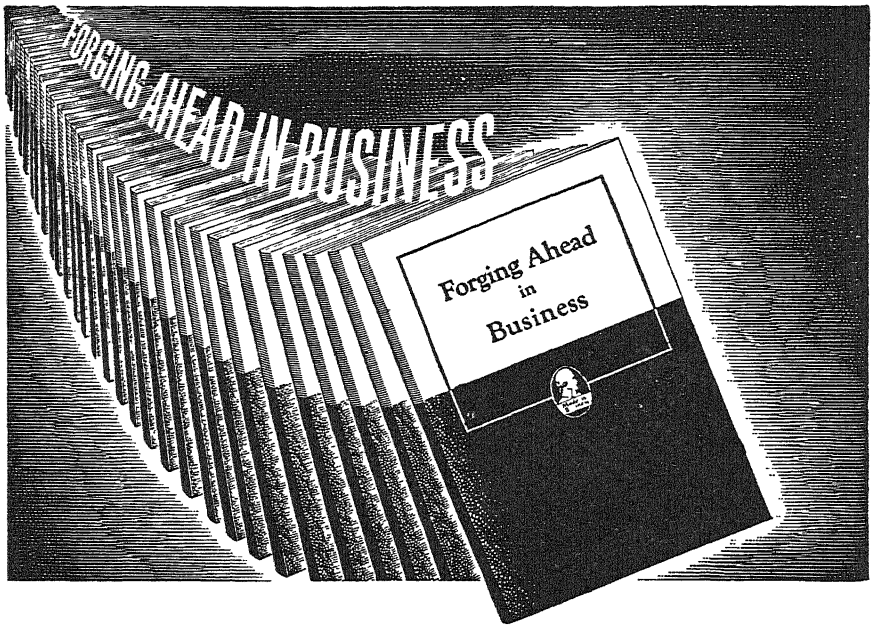


Bearing up well

He's carrying quite a load but he's doing all right. And he's mighty grateful for your help—especially when Long Distance circuits are crowded.

Then the Long Distance operator may say—"Please limit your call to 5 minutes." Saving telephone time is important in wartime.

BELL TELEPHONE SYSTEM



All Serious-Minded Production Men

SHOULD HAVE THIS FREE BOOKLET!

FORGING AHEAD IN BUSINESS contains a message of particular importance to production men. This is your opportunity to obtain a copy of this famous book, which has been described as a "turning point in the lives of literally thousands of men"!

Although "Forging Ahead in Business" has been distributed to more than 3,000,000 men, today's timely edition was written in the light of recent world-wide developments. Its 64 pages represent more than three decades of successful experience in training men for leadership in business and industry.

It demonstrates the method which the Alexander Hamilton Institute uses to give you immediate help in your present position, while preparing you for post-war opportunities. Subjects directly related to the work you are doing now, PLUS other subjects of fundamental value to the business executive, are discussed in the book and placed in significant relation to one another. Thus, a helpful, over-all picture is provided.

Said one man who had sent for "Forging Ahead in Business":

"In thirty minutes this little book gave me a clearer picture of my business future than I've ever had before."

. . . and that represents the opinion of the Institute's 400,000 subscribers, *including 134,000 production men!*

The booklet further explains how it is possible to offer this essential training in a minimum of time; how the Institute program fits in with the most crowded of war-time schedules.

Among the prominent industrialists who assisted in the preparation of the Course, which is described in "FORGING AHEAD IN BUSINESS" are: Alfred P. Sloan, Jr., Chairman of the Board, General Motors Corp.; Thomas J. Watson, President, International Business Machines Corp., and Frederick W. Pickard, Vice President and Director, E. I. du Pont de Nemours & Co.

Send for "FORGING AHEAD IN BUSINESS" TODAY!

Frankly, this booklet has no appeal for the immature mind. It does not interest the man who, for one reason or another, is wholly satisfied to plug along in a mediocre job. But, for the alert, future-minded individual—the man with ambition and "drive"—"Forging Ahead in Business" has a message of distinct importance. If you feel that it is intended for you, don't hesitate to send for a copy today. Simply fill in and mail the coupon below.

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Please mail me, without cost, a copy of the 64-page book—"FORGING AHEAD IN BUSINESS."

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Business Address.....

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"Quotes . . ."

"ONE HIGHLY IMPORTANT objective of post-war planning should be the creation of new opportunities for the productive efforts of our people. This is consistent with the sound principle that America's economy must expand in the future as it has in the past, a principle which the depression of the 'thirties' so convincingly demonstrated" *P W Litchfield, Chairman of the Board, Goodyear Tire and Rubber Company.*

" " "

"AN ORGANIZATION of intellectual workers can have the greatest significance for society as a whole by influencing public opinion through publicity and education Indeed, it is its proper task to defend academic freedom, without which a healthy development of democracy is impossible." Professor Albert Einstein

" " "

"RENEGOTIATION needs to have the mystery taken out of it Renegotiation in the mind of the average individual is a means for taking inordinate profits away from war production Obviously, if this is true every American would be for it The fact is, however, it does no such thing It rewards inefficiency and ruins the efficient all at the expense of the taxpayer." *J F. Lincoln, President, The Lincoln Electric Company*

" " "

"THE WORD 'BOOM' may be a bit strong, but we certainly do not anticipate a prolonged post-war slump. To meet war's requirements Diesel production has zoomed far beyond the highest point in the industry's history We expect this production to hold more or less firm." Gordon Lefebvre. President, Cooper-Bessemer Corporation.

" " "

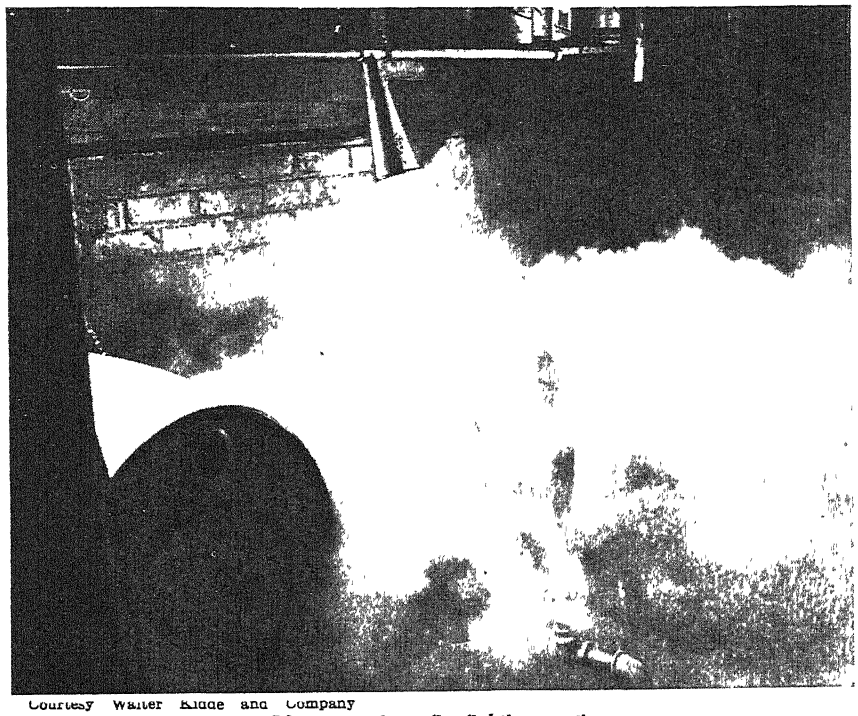
"NEW MARKETS will result from existing and expanding incomes, living standards and credit facilities This post-war 'look' spells unprecedented United States business prosperity in terms of our average family Educate and sell the other half of our fellow-beings our industrialized United States and the costs of this war in treasure will disappear." *George W. Bacon, Chairman of the Board, Ford, Bacon and Davis.*

" " "

"WE ARE RIGHT NOW in a period of intense inventive effort and accelerated scientific and engineering developments. The urgency of war has speeded up the clock In some lines, we are told, the probable developments of 20 or 30 years have been telescoped into three. . . There will be not only a tremendous accumulation of needs for engineers to meet, but also an extraordinary accumulation of new engineering knowledge." Robert M. Gates, President, American Society of Mechanical Engineers.

ENGINEERING

Conducted by EDWIN LAIRD CADY



Courtesy Walter Kidde and Company

CO_2 goes into fire-fighting action

Fighting Factory Fires

Fire Losses Do Not All Appear in the Statistics. Small and Unreported Fires are Quickly Controlled With Portable Equipment. But the Right Kind Must be at Hand at the Right Time, and Employees Must Know How to Use it. Water is Still a Good All-Around Extinguishant

BEFORE 1944 is over, fire losses in the United States will have climbed to another high for the past ten years. And industrial fire losses will have climbed right with them

Nobody really knows what the fire losses are Too few get into the statistics. If a loss is so big that somebody goes to his fire insurance company and puts in a claim for it, then that fire is called a "reported fire" and finds its way into the columns of figures. But a single cotton mill has been known to have 2000 unreported fires in a single month—lint around the bearings of a machine became oil soaked and caught fire by spontaneous combustion, and so on. Each of these fires was extinguished without physical damage to the machine—but each of them meant a machine temporarily shut down, men distracted from their work, supervisors dashing up with extinguishers. The total cost was plenty. but none of it was counted into the tables which everybody uses for studying fire hazards

Taking the figures as they are, then, fire losses cost the nation only $172,000,000 back in 1915. By 1926 they had hit an all-time high of $562,000,000. Gradually they were knocked down to the $235,000,000 of 1935. Since then they have again been growing. and 1943 saw them jump up to $380,000,000 from the $314,000 000 of 1942 They are going at an even hotter pace in 1944

These figures, of course, do not begin to compare with the $2,000,000,000 per year cost of industrial accidents. (And we will not mention the daily cost of the war this time.) The fact is, the $100,000,000 per year cost of industrial fires—and industrial fires run from 23 to 28 percent of the total—represents one of the greatest triumphs of industrial history.

But, in spite of all this, industry is not regarding its fire situation with complacency. Too much can get out of hand in too short time. Just one good blaze in a big war plant could send the figures soaring.

And there are definite reasons to believe this may happen. The growing number of electrical fires is one of them. Over a ten year average, electricity was a poor fifth in the amount of damage done by fires. Matches (smoking) nearly doubled electrical causes in damage done. But during the past year or so, electrical fires have taken the lead. They are 50 percent greater than their old matches-smoking rival.

Greatly increased use of flammable solvents and other liquids is another hazard. New flammable raw materials —magnesium is one of the most dangerous—present new problems The crowded conditions of modern factories, with complicated equipment fitted in wherever space can be found from floor to ceiling, and closed ducts threading their way everywhere, do their share to make fire protection men

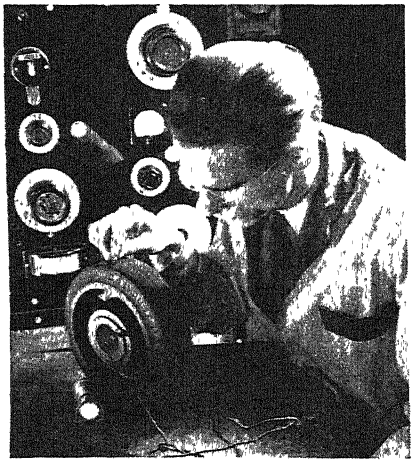
feel unhappy This trend increases

ELECTRICAL FIRES—Even though electrical fires are growing in numbers, they have not grown anywhere near so fast as the amounts of electrical equipment and power used.

One good reason for this is that fighting of the electrical fire starts with the building of the electrical equipment. Modern electrical insulating materials are far more fire resistant than their predecessors. And, even more important, thermal protections are built right into equipment—a large generator may have thermal devices which will shut it off if even a few degrees rise in temperature should occur in its interior parts And the art of using fuses has improved. The time-lag fuse which permits a temporary overload but blows if electrical overload is protracted enough to be a fire hazard, has nearly ended the old time custom of over-fusing to get rid of the trouble of replacing fuses. Quickly replaceable safety fuses and other safety devices have done their share

Large industrial plants have added the automatic extinguishing set-up which goes into action the minute the fire starts. Perhaps the best of these are the carbon dioxide (CO_2) systems Nozzles leading from these are mounted not only to extinguish the fire itself, but to put shielding clouds of the carbon dioxide between the fire and nearby materials to which the fire might spread These nozzles are inside cabinets, behind panels, at large motors—often the nozzles are so inconspicuous that few workers realize they are there until a fire starts.

High pressure, one of the old bugaboos of CO_2 system, has been laid during the war. Pressures of the order of 850 pounds per square inch have long been used for small units, and large units have been built by installing many small ones in series. Now by the use of refrigerating systems the carbon dioxide can be kept at zero, Fahrenheit, and stored at only 300 pounds per square inch. As a result, more than 100 tons may be stored in a single tank—a procedure which was mechanically possible but economically



Courtesy B. F. Goodrich Company

This industrial truck tire and wheel will conduct electricity, reducing possibility of static sparks that might start fires in flammable vapors

GASES AND VAPORS, AND OF COMMON REFRIGERANTS

Gas or Vapor	Vapor Density (Air=1)	Rate of Diffusion (Air=1)	Explosive Limits % in Air by Volume Lower	Upper
Acetic Acid	2.1	0.69	4.0	
Acetone	2.0	0.71	2.0	9.0
Acetylene	0.90	1.05	2.6	82
Alcohol (Ethyl Alcohol)	1.6	0.79	3.5	19.0
Ammonia	0.59	1.30	16.0	25
Amyl Acetate	4.5	0.47	1.1	4.0
Amyl Alcohol	3.0	0.58	1.2	5.0
Benzine	3.0	0.58	1.4	5.9
Benzol (Benzene)	2.7	0.61	1.4	8.
Butane	2.0	0.71	1.6	6.5
Butyl Acetate	4.0	0.50	1.7	
Butyl Alcohol	2.6	0.62	1.7	18.
Carbon Bisulphide	2.6	0.62	1.0	50
Carbon Dioxide	1.5	0.82	Non-flam	
Carbon Monoxide	0.97	1.02	12.5	74
Dichlorethylene	3.35	0.55	5.6	11.4
Dichlorodifluoromethane (F-12)	4.2	0.49	Non-flam	
Dichlorotetrafluoroethane (F-114)	5.9	0.41	Non-flam.	
Ethane	1.03	0.98	3.3	10.6
Ether (Ethyl Ether)	2.6	0.62	1.9	22
Ethyl Acetate	3.0	0.58	2.5	11.5
Ethyl Bromide	3.76	0.51	6.0	11.0
Ethyl Chloride	2.2	0.67	3.7	12.0
Ethylene	0.97	1.02	3.0	34.0
Ethylene Oxide	1.5	0.82	3.0	80
Gasoline	3.5	0.53	1.4	6
Hydrocyanic Acid	0.93	1.04	5.6	40
Hydrogen	0.069	3.81	4.1	74
Hydrogen Sulphide	1.17	0.92	4.3	46
Illuminating Gas	0.65	1.24	5.0	31
Kerosene	4.5	0.47	1.1	6
Methane	0.55	1.35	5.6	13.5
Methyl Acetate	2.6	0.62	4.1	14
Methyl (Wood) Alcohol	1.1	0.95	6	36
Methyl Bromide	3.3	0.55	13.5	14.5
Methyl Chloride	1.7	0.76	8.1	17.2
Methylene Chloride (Dichloromethane)	2.9	0.58	‡	‡
Methyl Formate	2.1	0.69	4.5	20
Monofluorotrichloromethane (F-11)	4.7	0.46	Non-flam	
Pentane	2.5	0.63	1.45	7.5
Propane	1.5	0.82	2.3	7.3
Propylene	1.45	0.83	2.2	9.7
Sulphur Dioxide	2.2	0.67	Non-flam	
Toluol (Toluene)	3.14	0.56	1.4	7
Turpentine	4.7	0.46	0.8	
Xylol (Xylene)	3.7	0.52	1.0	5.3

‡Practically non flammable at ordinary temperatures.

impractical at the higher pressures. This is important to large electrical installations.

Portable carbon dioxide extinguishers have been improved, too, in that the operator has better control; by merely varying the pressure of the grip of his hand he can increase or decrease the volume of CO_2 he directs at the fire. And perhaps the greatest factor in all the CO_2 extinguishers is that over the years so many factory employees have become familiar with them, have learned what they are for and how to operate them The small electrical fire finds one of these, or a dry chemical or vaporizing liquid type, directed at it at once.

Fear of using water on an electrical fire is being dissipated with excellent results. In former years many an electrical fire got completely out of control just because the fire fighting forces had only water hoses at hand and were afraid of electrocution. But the National Board of Fire Underwriters has found that, on ordinary 120-volt lines, a hose nozzle can be brought to within a few inches of the live wire or device and so long as the nozzle itself does not make an actual electrical contact with the wire the fireman can work in perfect comfort, especially if he is wearing rubber boots.

Higher potentials are more dangerous, but not excessively so. At 600 volts, the National Electrical Code limit for low potential, the nozzle can be brought to within four feet of the charged wire. Even 2200 volts is OK at 11 feet, and 33,000 volts can be squirted upon from 30 to 40 feet.

The modern fog nozzles present an even better picture. If the nozzle is held at least six inches away from the live wire, the fog device is safe up to 7500 volts And a really hot 220 000 volt job is safe if the nozzle is 11 feet away

As a result of these safety figures, water streams are being used to cool down electrical fires until the CO_2 or other extinguishant can be brought into play Fog nozzles are mounted as automatic equipment for the same purpose. Neither water nor fog will penetrate to the inside parts of electrical equipment as carbon dioxide gas will, and nobody wants to get electrical equipment wet if he can help it, the drying out process is too time-consuming and costly But electrical fires can be cooled with water, they can be stopped quickly with CO_2, and damage from them in industry is being kept astonishingly low

FLAMMABLE LIQUIDS AND GASES—Flammable liquids are being used in industry in ever-increasing quantities, especially as solvents and refrigerants. Their greatest danger is in the gases they give off—gases which may be explosive if mixed with the correct quantities of air A spark or other source of fire contacting such a gas at a distance as great as 150 feet from the liquid itself may start a fire.

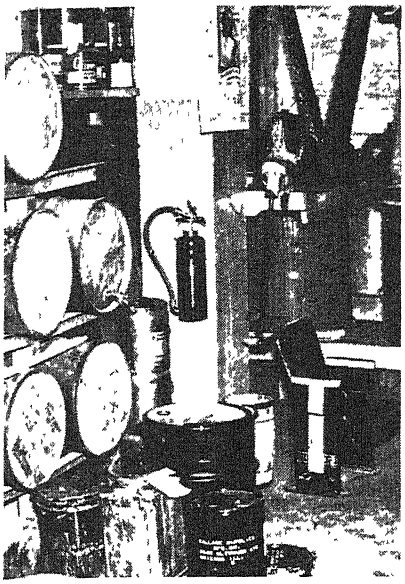
First step in controlling these fires has been to know the speeds at which the gases or vapors diffuse in air, and the upper and lower limits of vapor-air mixture at which combustion or explosion can take place. Based on this knowledge, devices are used to evacuate the fumes before they reach explosive proportions, or, better still, to recover the fumes and prevent waste Many systems using these liquids and gases are completely closed, the fumes do not escape to become dangerous

Chambers, paint spray rooms, and other places where such fumes may gather, often are protected by automatic CO_2, water fog, or other extinguishing systems which act so quickly that the fire may be put out before plant employees find out that it has started Many of these systems are so arranged that shields of extinguishant are thrown between the fire and nearby equipment The fire is isolated

Automatic hoods, louvers, shutters, and doors are arranged to isolate the fire and cut off its oxygen supply Many of these work by gravity—one of the simplest devices is to have a fusible link of the same metal as that used in sprinkler heads The link melts from the heat of the fire, and the hood or other device operates by its own weight or by a weight attached to it

In some of the best systems the extinguisher and the isolating devices are connected When the fire causes the extinguisher to operate, change of pressure in the extinguisher piping (or some other device) actuates valves which drop hoods, close louvers, shut off ventilating and other fans, and ring alarms.

One of the fastest growing means of control of this type of fire is the increased use of non-sparking tools. Pliers, wrenches, hammers, chisels, almost every kind of tool which might



Dry chemical fire extinguishers are spotted strategically in a paint mixing room, ready for instant use

slip, be struck, or be dropped in such a way as to cause a spark if made of steel, are now made of non-sparking metal.

First used in gunpowder plants but now transferred to industry in general is the static electricity conducting conveyor belt, industrial truck tire, safety shoe for workmen, and factory flooring. Stray electrical currents generated by friction or otherwise are conducted away before they gather enough potential to cause the sparks which would set off explosions and fires

Portable extinguishers of the dry chemical, CO_2, vaporizing liquid, and foam types are highly developed for controlling these fires. Like other portable extinguishers, one of the chief values of these lies in the fact that factory employees can quickly learn how to use them.

MAGNESIUM FIRES — Magnesium threatens to take the place of celluloid as the most feared flammable material used in industry. Like celluloid it has a secondary hazard. The gas which is a product of combustion of celluloid is itself explosively flammable; magnesium has the property of taking oxygen out of the water used to extinguish its fires and so of propagating and even increasing the intensity of its burning.

The greatest danger from magnesium fires exists, not for the war plants which have learned about magnesium and how to handle it, but for the myriads of small plants which may experiment with this metal to take advantage of its lightness and strength for their post-war products.

The National Board of Fire Underwriters is preparing special data to show factories how to control this hazard. Absent from this will be the weird tales of factories which forbade their women operators to wear silk panties (if they could get any) lest sparks from friction set off the magnesium chips in their lathes. Gone also will be the superstition that water should never be used on a magnesium fire. The fact is, so long as a solid stream of water is not used to scatter the fire, water has the useful effect of cooling down the blaze, cutting off the heat radiation which is one of the principal means by which magnesium fires cause other materials to inflame, and making it easier for the dry chemicals to extinguish the fire.

Many types of extinguishants can be used with success on magnesium fires. Graphite has been used and there are special dry chemicals of water-repellant types. Dow Chemical Company, world's largest producer of magnesium, has an extinguishant.

ORDINARY FIRES—The common fires in wood, rubbish, paper, and so on are being kept down by modern good housekeeping. Factories are kept cleaner than ever before. There are fewer accumulations of rubbish and less dust is permitted to pile up in concealed places. After all, fires must have fuel and the hazards are less when the flammable trash is kept out of the plant.

The increased use of flame-proof or flame-resistant materials is a second step in this control. This includes not only stone, concrete, steel, glass, tile in the walls and floors, but also wood which has been so treated that it will not support combustion.

A third factor in general fire control is the completeness with which wood chips, oil-bearing metal chips, and other scrap is being scavenged at its points of origin. Much of this method originated not as a means of fire control at all, but of salvaging critical materials, keeping process temperatures under control, and keeping operations clean. Fire damage per million dollars' worth of goods produced, or per thousand kilowatts of connected horsepower, or other yardstick, is due to keep on going down in industry—unless somebody gets over-confident and looks the other way while hazards build themselves up.

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MORE LADDERS

Designed for Other Purposes, They Aid Maintenance Men

INDUSTRIAL maintenance men have more types of ladders, moveable platforms, portable man hoists, and so on, available to them than ever before. The result is greater speed in maintenance operations on shafting, fans, blowers, motors, conveyors, and all sorts of devices mounted over head.

These ladders were not developed for industrial maintenance. They have come into existence because airplane maintenance and some parts of aircraft construction require more climbing by more men who must have more portable tools with them than any other task industry has experienced. Speedy equipment had to be developed for getting the men up where they could work, and it had to be equipment which could be removed quickly.

The common extension ladder helped some, and so did the platform or safety ladder. But aircraft plants developed "wheelbarrow" platforms, which are wide portable staircases having two of their supports on wheels and two on ladder shoes These platforms may be wheeled by hand wherever wanted. The ladder shoes are set on the ground in the regular way and hold the platforms in place while the men work.

Portable and demountable man hoists capable of being erected in odd or tight corners or of being made large enough for several men to work on one platform also were developed. Transferred to the factory for painting and other maintenance work, these devices are time savers.

PERMANENT MOLDS

Produce Satisfactory Cast Iron

PERMANENT mold casting of iron was one of the most talked-of production processes just before the war. Now, with the shortage of brass and bronze, manufacturers have had to turn to this process as the best way to get some of their substitute parts.

The process, developed by Eaton Manufacturing Company, is working. It produces a fine-grained homogeneous metal which compares well with brass and bronze in machinability. Intricate shapes are being produced. Tests show that the metal is practically free from porosity.

Nobody knows how far this process will get in the post-war field—it will have to take what it can grab in the forthcoming battle between nonferrous metals, stampings, forgings, die castings, plastics, glass, and all. But at least permanent molds for iron are well beyond the dream stage.

TUBULAR AXLES

Developed for Railroads, Have Other Possibilities

TUBULAR steel axles, a development of the Pittsburgh Steel Company, are being watched with great interest by builders of heavy machinery. Right now these axles are made only for railroad cars; they save from 25 to 40 percent of the weight of the solid axle and give the locomotive a minimum of 1040 fewer pounds a car to haul.

The manufacturing process includes special rolling to form the axle shape for wheel seats and the like, special upsetting, forging and heat treating. No other industry than railroads provides the volume of business on heavy axles to warrant the working out of this process. But, once the process is in full swing, sizes may be made for makers of chemical machinery, heavy machinery for oil refineries, heavy machine tools, and so on. Some machine designers are thinking of incorporating standard shape railroad car axles into their original products.

Nonferrous Metals Tomorrow

The War Has Framed the Futures of the Nonferrous Metals With a Number of Provocative Question Marks. How Will Aluminum, Magnesium, Copper, Zinc, Lead, and Other Important Metals Fare Individually When Peace-Time Competition Really Gets Tough? Some of the Answers are Clear Now

ONE MORNING last winter the public read with puzzlement that WPB had ordered the suspension of production at one of the East's new aluminum manufacturing plants, because aluminum output had surpassed the demand for the metal in aircraft and munitions.

Then, in March, magnesium production was cut back some 34 million pounds per year or about 6 percent of the total program. Reason: too much magnesium already. Copper became plentiful enough for Ordnance to effect a return to brass shell cases instead of using substitute steel If the production capacities of these industries are too great now, with war unfinished, what situation will they be in when peace and competitive markets return?

Of course, many factors of a non-technological nature—such as national and international economic policies and politics—may ultimately decide their fates. But assuming a free economy based on "private enterprise" it is possible to make some reasonably safe predictions as to the technical paths the individual metals will follow, the markets they may reach and the extent to which their generally expanded war-time production capacities may be used.

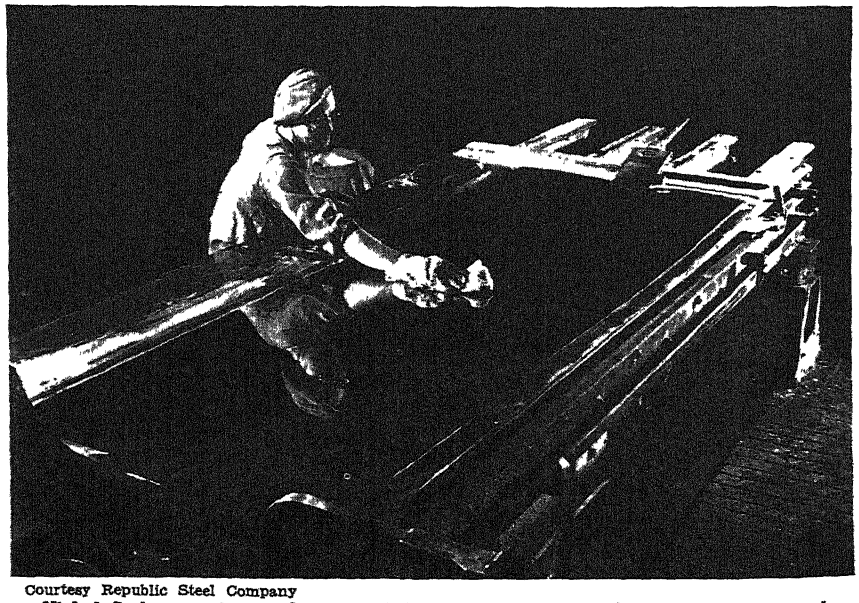
NO THREAT TO STEEL—In the first place, let us dispose finally and briefly of the fear occasionally voiced that the light metals will present a major threat to the steel industry. Today steel production is over 90 million tons of ingots, a figure that utterly dwarfs the light metals total of less than 1½ million tons a year. As a matter of fact, some of the steel industry's specialty items like stainless steel or low-alloy high-strength steel may present a greater threat to the light metals than the latter do to the steel industry as a whole. It is to each other that the nonferrous metals may do the most harm.

The present production of aluminum is in the neighborhood of 1,000,000 tons per year. Its price is now around 15 cents per pound for primary (virgin) aluminum ingot. The expectation is that after the war this price will drop to 11 or 12 cents and that the price of secondary (reclaimed) aluminum may be close to six cents per pound. This price situation places aluminum in a more favorable position marketwise than copper and its alloys, since their prices per pound will be very close together while the price per unit volume of aluminum will be proportionately lower because of its lower specific gravity.

Few, however, expect the production of aluminum to be any larger than it is at present for some time after the war's end. This is because the metal's present chief market (aircraft) will shrink in production to an expected small fraction of its present volume and it will doubtless be some time before that industry re-reaches its present level and before the aluminum and magnesium manufacturers will have developed other markets to occupy their manufacturing capacity completely. In this respect, of course, political developments will have considerable influence, since the question of possible governmental operation or "bargain sale" of the Government-owned aluminum plants is still open.

Despite this, of all the nonferrous metal manufacturers the aluminum industry is expected to be the most aggressive in capturing or developing post-war markets for its materials The chief advantage of aluminum alloys—their high strength-weight ratio—makes them especially attractive for mobile equipment of various types since it is expected that the post-war period will see rapid expansion in the "vehicular" industries (which profit in proportion to their use of light-weight materials). We may safely predict extensive use of aluminum alloys in railroad equipment, including locomotives as well as freight trains and de luxe passenger cars; in automobile engine parts (but not in bodies for some time); in busses, trucks, and trailers which can carry more payload or operate at higher speeds as they reduce their weight; and in the new civil aircraft industry which, starting from a low level, may be expected to grow over a period of years as did the automobile field.

IN HEAVY MACHINERY—Aluminum alloys will certainly be used in machinery for normally heavy parts (like turret heads for lathes) and for reciprocating parts that must stop fast without loss of energy. Things to be carried will also be a wide-open market for light-weight aluminum—hand tools such as shovels, electrical appliances, cameras, and so on. A very large aluminum market will probably be its use for electrical transmission lines, where its lower weight as compared to copper



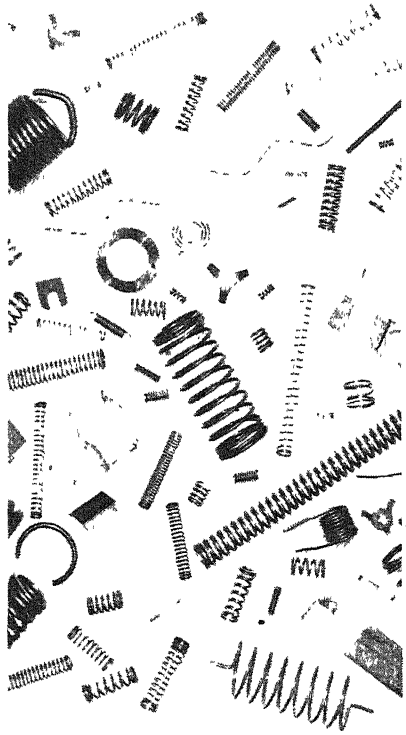
Courtesy Republic Steel Company

Nickel finds a major market in stainless steel, whose applications are expected to expand in many fields after the war. Here a stainless steel sheet is polished

permits the use of fewer steel supporting towers.

In addition to these, innumerable "new" minor markets will be developed, such as cigarette foil, carboys for certain chemicals, heat-conductivity items, mirrors and reflectors, hypodermic needles, toothpaste and shaving cream tubes, milk bottle caps, beer barrels, and so on. A significant feature of the post-war market for aluminum will be the possibility of using large amounts of secondary metal—even larger in proportion than is now possible because of limitations written into aircraft specifications

Much of what we have said about aluminum applies in a smaller degree to magnesium. Magnesium production is now at the rate of about 300,000 tons per year Magnesium primary ingots are priced at about 21 cents per pound. After the war the primary price may go down to 15 cents and the price of secondary magnesium to 10 or 11 cents per pound. These prices are very close to those of aluminum on a volume basis, which is the basis on which metals inevitably compete.



Courtesy Instrument Specialties Company

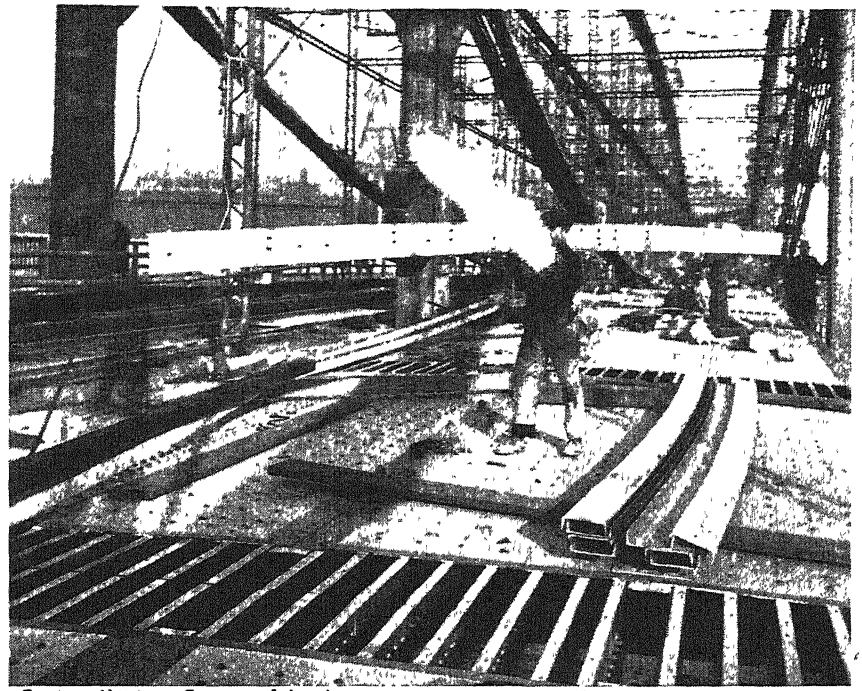
Relatively new member of the family of copper alloys is beryllium copper, whose post-war prospects, especially in the field of fine springs like these, is very bright

It is unlikely that magnesium will be used to anything like the same extent as aluminum for massive structural parts of vehicular equipment since the material does not lend itself to cold fabrication of sheets and bars as easily as aluminum, but it certainly will be a major competitor of the other light metal for the manufacture of countless smaller parts required to be light in weight, especially in the form of castings, die castings, forgings, or extrusions. Magnesium at present lacks some of aluminum's corrosion resistance but this can be corrected by the application of surface treatments.

Magnesium will have to fight for its markets and in the opinion of many will have a difficult time keeping its present manufacturing capacity occupied for some time after the war. A problem in this latter respect is the large amount of magnesium-powder production facilities built to manufacture magnesium powder for incendiary bombs and flares, for which there is as yet no visible powder-metallurgy market.

Portable tools, vacuum cleaners, floor polishers, radios, cameras, and similar equipment that benefits from light weight will be a market for magnesium as it is for aluminum. Magnesium does not have aluminum's high electrical conductivity nor its ability to be rolled into foil, so it will not compete for these applications, but it will compete strongly for engine and machinery parts of various types.

The picture for magnesium is fraught with more uncertainties than one finds with some of the other metals whose post-war situation is under study. Many engineers feel that magnesium does have a bright future but that many new ones for it need to be developed, since they have not existed in the past.



Courtesy Aluminum Company of America

An aluminum-alloy floor system being incorporated in a bridge reconstruction job. Wide use of aluminum for such purposes is expected in the post-war period

COMPLICATED TRANSITION—The future applications of copper are generally expected to be quite similar to those in which the metal was used before the war. Most of these applications are stable and a surprisingly large proportion of them are well able to resist competition from the light metals or from alloy steels. The vast use of copper and its alloys in war production, especially ammunition, will greatly complicate the transition from war uses to peace uses and may even delay considerably the "reconversion" of copper application to civilian purposes.

The important uses of copper that are expected to survive in large measure are as conductive material in electrical equipment, in communication lines, in electrical power lines, in automobiles, and in buildings. Typical of the electrical products in which it will find extensive use are generators, motors, locomotives, switch boards, light bulbs, and so on.

In few of these parts will it be possible to displace copper with a conductor metal like aluminum, for weight is a less important factor than the mechanical and heat-resisting properties of the conductor material. For power lines, however, aluminum will probably challenge copper to a considerable extent although here again copper has other advantages over aluminum that may offset the weight differential in the eyes of some engineers. In general no matter what happens to the specific applications of copper in electrical products and power lines, the whole field of electrical generation, distribution, and use will probably expand so greatly as to assure an expanding field of use for copper therein.

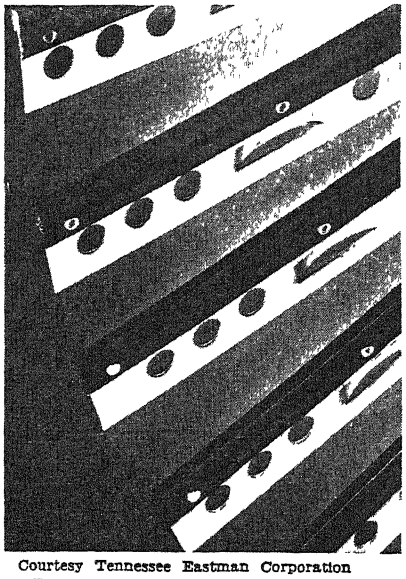
The other two major markets—automobiles and buildings—are universally expected to be among the foremost "boom" industries of the early post-war years and copper should share heavily in the growing markets for materials they provide. In automobiles the copper alloys have many uses, especially in starters, generators, and ignition equipment, bearings, and so on. These will largely be maintained despite attempts to replace them by other materials.

The use of copper in the marine field, which has always been large and represets a considerable maintenance and replacement business for the metal, is also a permanent thing, since the chief property of copper that is applied here is its resistance to sea-water corrosion.

No other material has that kind of resistance to a comparable degree

One of the most interesting features of copper is that in a majority of the war-time applications of other metals as a substitute for copper alloys, the people who made the substitution are extremely eager to return to the original copper alloy as soon as possible and have generally regarded the substitutes as emergency makeshifts

The future of zinc at the moment is somewhat complicated by uncertainty as to the amount of first-class ore reserves that will be available for several



Courtesy Tennessee Eastman Corporation

A war-time development that may remain in post-war use is division stripping for Terrazo flooring. Formerly made of brass or bronze, they are now made without loss of beauty or durability in colored plastics attached to galvanized iron strips

years after the war. There is no prospect of exhaustion of our zinc supplies but there is a possibility that the price of zinc may be somewhat higher in time because of the extra cost necessary to extract it Its major uses—in galvanizing, in brass making, and in die casting—will, however, suffer or enjoy varying fates.

Zinc will lose some of its galvanizing market to lead-coated sheet and to black oxidized sheet, about which manufacturers and users have learned much during the war. But, basically, zinc will retain a large majority of the uses for galvanizing that previously existed and in addition will share to a large extent in the expansion in use of coated materials that will follow the war. War-time restrictions forced many consumers to shift from metals that were corrosion-resistant throughout to those that had a corrosion-resistant layer on the surface, and galvanized steel was applied in many instances in place of stainless steel or brass formerly used. And a powerful factor will be the astonishing backlog of unfilled demand for galvanized sheets in the early post-war years, revealed by one recent survey.

The comments on brass made in the preceding section on copper apply, of course, to zinc in reference to its use as a constituent of brass With respect to die castings, however, it is difficult to make a prediction. The use of die casting as a metal fabricating process has expanded tremendously during the war and should be on a higher level after the war than in 1940, but a large measure of that expansion is represented by aluminum die castings It is certain that in the post-war period the proportion of the total tonnage of die castings made in aluminum will be much higher than it was before the war and, in fact, aluminum may in time replace zinc as the chief die-casting metal On the other hand, zinc is already finding use in tiny die castings like zipper components, where the low melting point and fast-production possibilities of zinc die castings provide an appeal not offered by other die casting metals.

Zinc has many other uses that are somewhat specialized and which may not be seriously challenged by competitive materials. Rolled zinc used for battery cans, photoengraving, in automobiles and refrigerators, and for glass jar tops should retain a large part of its earlier market.

The probable future positions of silver and of lead have been indicated in earlier articles in Scientific American (October 1943 and June 1944).

Nickel stands to benefit heavily from the great expansion in use of electronics, which will continue into the post-war era, for a large proportion of the metal wire and strip in every electronic tube is nickel or a high-nickel alloy. The heater-wire application for 60 to 80 percent nickel alloys will increase, too, as rural America expands its use of electric appliances. The future of nickel's chief outlet—as an alloying agent for steel—is bright, since alloy steels and especially stainless steels (which contain up to 25 percent nickel) are expected to reach new consumption peaks in post-war years

These are the pros and cons of the expansions or curtailments in use of the individual major nonferrous metals. You may have noted that the picture thus painted is relatively bright. It is so intended; although the transition and early post-war years may be tough, we have faith in an ultimately expanding American industrial economy, with plenty of room for all the important materials of construction

STRONG ALUMINUM ALLOYS

Also Have Improved Corrosion Resistance

SINCE the war began, the American aluminum industry has not only boosted its production several fold but has also developed new treatments and alloys to provide higher strength aircraft components. Thus the familiar 24ST alloy, which under pre-war standards could be produced with a tensile strength of 60,000 pounds per square inch and a yield strength of 38,000 pounds per square inch, has had its tensile strength raised to 69,000 and its yield strength to 65,000 through a special heat treatment.

Even more notable are two new aluminum alloys (like the treatment just mentioned, the compositions of these alloys are still military secrets) called XA75S and XB75E, which have higher physical properties than 24S and improved corrosion resistance.

These alloys, now recognized officially through the issuance of Army-Navy specifications for them, are being manufactured in sheet form for skin structures. Their good corrosion resistance is expected to bring sheet aluminum into competition with coated iron and steel and with copper and brass sheet products for many post-war applications.

BLACKENING STAINLESS

Accomplished by New Treatment Method

THE BLACKENING of stainless steel parts, often required for ordnance work, has conventionally been done by japanning, electroplating, enameling and so on, because the chemical and electrochemical processes commonly used on ordinary steels have been unsatisfactory. The externally applied coatings, in turn, have suffered from brittleness, poor adhesion, or inadequate wear resistance, according to *Steel* magazine

Rustless Iron and Steel Company, however, has recently developed a method for the surface blackening of 18 and 8 and of straight-chromium stainless steels by treatment in molten sodium dichromate at temperatures higher than 615 degrees, Fahrenheit. Best temperatures are 730 to 750 degrees for 15 to 20 minutes

The black coating so produced is adherent, permanent in color, and actually improves the corrosion resistance of the basis metal in several corrosive media.

ELECTRONIC CONTROL

Automatically Guides Metal Flame Cutter

AN ELECTRONIC control designed to guide automatically a gas cutting machine completely around a template that consists simply of a pencil drawing on white paper is one of the latest time-savers in metal-processing. The operator is relieved of guiding the driving wheel around the template and can instead plan his next job or adjust the torch or cutting speed.

The outfit, described by R. D. McComb in the *Journal of the American Welding Society*, consists of a light source and lens combination that projects a small spot of light on the template. One or more phototubes receive the light reflected back from the template, the amount of which is much more when the spot is off the pencil mark than when it is on it. The amount of light received by the tubes causes them to operate an electric signal that pulls the cutting machine back to its correct position whenever it tends to leave it. A smooth, clean cut results.

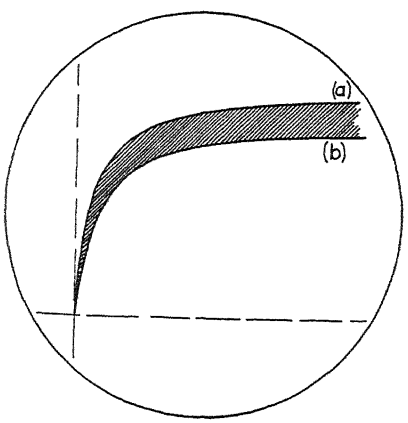
Electronic Sorting

Automatic Operation is Attained With the Cathode-Ray Tube. By Blacking-Out Part of the Tube's Screen, Light Shows Only When Defective Parts Pass on the Production Line. A Photocell Watches the Screen and Actuates a Reject Mechanism When it Sees Light, Giving Highly Accurate Results

In routine production tests, occasions often arise where it is desirable to check the entire characteristic curve associated with a product or process. Examples include checking the characteristics of a radio tube, checking the frequency response of a microphone or amplifier, or checking the spectrophotometric curve of a colored object.

Where it is possible to arrange the test so that the variation to be observed is repeated at short, regular intervals, a cathode-ray oscilloscope can generally be used to make the desired curve visible on a fluorescent screen. But this ordinarily means that an attendant must watch the glowing pattern and take suitable action when the curve for a particular object under test deviates excessively from the desired curve. A method developed recently by Leland L. Antes of the Bureau of Engineering Research, The University of Texas, eliminates the need for an attendant, however, by uniquely employing a phototube to watch the pattern.

The automatic electronic method of testing has many production-line applications, dividing into two groups. Electrical characteristics of test specimens are utilized directly in the first group, and testing of vacuum-tubes can be considered as a typical example to be taken up in detail. In the second group of applications electrical characteristics are derived from colors, sound, or other primary factors, and here the sorting of colored tiles has been selected as a representative example.



Cathode-ray oscilloscope screen, showing the mask pasted on the screen between the upper (a) and lower (b) tolerance limits for the plate voltage-plate current curve of a particular vacuum tube under test

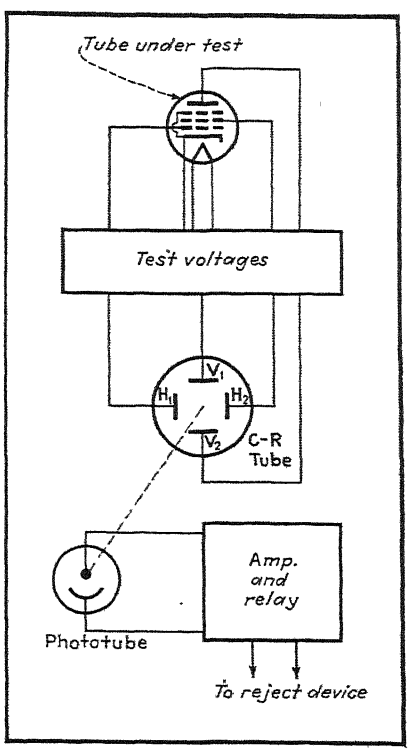
The manner in which the plate current of a vacuum tube varies with plate voltage is one characteristic that is a good indication of tube quality over its entire operating range These variations of plate current are plotted on graph paper as a curve and normally must be made by connecting the tube in a test circuit where variable controls permit changing the plate voltage in steps A meter in the circuit then permits readings of the plate current to be made, and these are laboriously plotted as points on the graph to form a complete characteristic curve. Such a procedure requires considerable time to accomplish and cannot be done economically on a mass production basis.

INSTANTANEOUS CURVES—With the cathode-ray tube, the characteristic curve can be plotted instantaneously on the phosphorescent screen. To do this, the tube under test is connected into a circuit where the applied voltage is periodically varying from zero to some high value. Such a voltage can be obtained from an electronic rectifier supplying pulsations of direct voltage This voltage and another voltage that can be produced by the current flow through the tube under test are applied to deflection plates inside the cathode-ray tube.

The deflection plates, when supplied with the correct potential or voltage, can cause a stream of electrons to move across the screen at the end of the tube. This electron stream or beam is produced by a set of electrodes which are part of the so-called electron gun. The gun consists of a cathode to throw off the electrons, a grid to control the flow, and two tubular anodes that operate in much the same manner as the screen grid and plate in a conventional receiving tube. The additional function of the two anodes is to confine the electron stream into a narrow beam that produces a small dot of light when it strikes the phosphor coating on the end of the tube. The same construction is used in the picture tube contained in all present-day television receivers.

When the cathode-ray tube is mounted horizontally, it is oriented so that one pair of deflection plates is mounted vertically and a second pair is mounted horizontally. The electron beam passes through the center of the rectangle formed by the plates. When a voltage is applied to one pair of plates, the beam is attracted toward the positive plate to a degree determined by the amount of voltage. Thus, the higher the voltage, the greater is the deflection of the beam from the center position, and the greater the movement of the spot of light on the screen. In this manner, the plates mounted vertically are able to deflect the electron beam from side to side across the screen, while the horizontally-mounted plates deflect it up and down.

The material of which the phosphor screen is made is able to retain its glow for a short period after the electron



Block diagram illustrating method of automatically rejecting defective vacuum tubes photo-electronically

beam has passed, and this persistence of glow permits the moving spot to inscribe what appear to be continuous lines on the screen. The shape of the pattern on the screen is controlled by the voltages applied to the deflection plates and, in the case of the television tube, the rapid voltage changes produce the complete picture.

To plot the characteristic curve of a vacuum tube, the vertical deflection plates are supplied with the same voltage as applied to the plate of the tube under test, and the horizontal deflection plates are supplied with a voltage that is proportional to the current flow in the tube. This voltage is easily obtained by inserting a resistor in the cathode circuit of the tube so that the voltage drop across the resistor is proportional to the plate current flowing through it. As a result, the screen of the cathode-ray tube shows the complete curve of plate voltage versus plate current as soon as the tube is connected into the test circuit.

CONVEYOR-BELT TESTING—In production testing of vacuum tubes by this method, the tubes can be fed to the test circuit on a conveyor belt and be automatically or manually connected and removed. Tolerance limits can be set up by marking the screen of the cathode-ray tube with the curves of two tubes, one at the upper limit and one at the lower limit required. The space between the two curves can be covered with black tape so that no glow will show on the screen when the tube is within the proper limits. Tubes exhibiting a characteristic curve outside this covered area are then rejected by the operator.

Automatic rejection without an operator can be provided by arranging a phototube in front of the screen of the cathode-ray tube so that the glow of the curve produced by a defective tube will actuate the phototube and cause an electronic amplifier to control the mechanical operation of removing the defective tube from the conveyor belt.

Other applications of the procedure just outlined can be made by engineers who deal with testing or sorting problems in other industries in which an entire characteristic curve of a device must be considered. Thus, the frequency response of sound-producing devices, microphones, amplifiers, and filters can be checked at a rapid rate. Almost any product that can produce a voltage, change in electrical conductivity, or change in magnetic effect can be quickly sorted by this cathode-ray method.

The sorting of colored tiles as they emerge from kilns on conveyor belts is an excellent example for the group of indirect applications. Here the primary factor that determines acceptance or rejection of each object is a very small difference in color, and these color variations must be converted into electrical variations capable of producing a characteristic color curve on the cathode-ray tube screen.

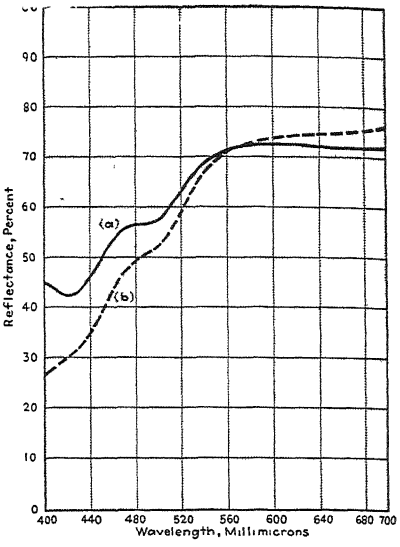
Sorting of tiles is necessary because the different temperature and atmospheric zones in a kiln produce slightly different colored glazes, and because different colored glazes are often placed in a kiln at the same time to utilize the different firing zones to best advantage. The method of sorting the tiles as they emerge after firing must, if it is to compare with the human eye in efficiency, involve a precise method of defining the exact color desired at each sorting station. Since each station will pass one desired color and reject all the rest, the number of sorting stations employed must be one less than the number of colors into which the kiln output is to be sorted.

Probably the most precise method of defining a color is that which makes use of a spectrophotometric curve. This curve gives the percentage of light reflected by the color sample at each wavelength in the visible spectrum. Each wavelength or color of light in turn is directed on the sample and the amount of reflected light is measured. The results are then plotted as percent reflectance against wavelength, for two different color samples of enameled porcelain.

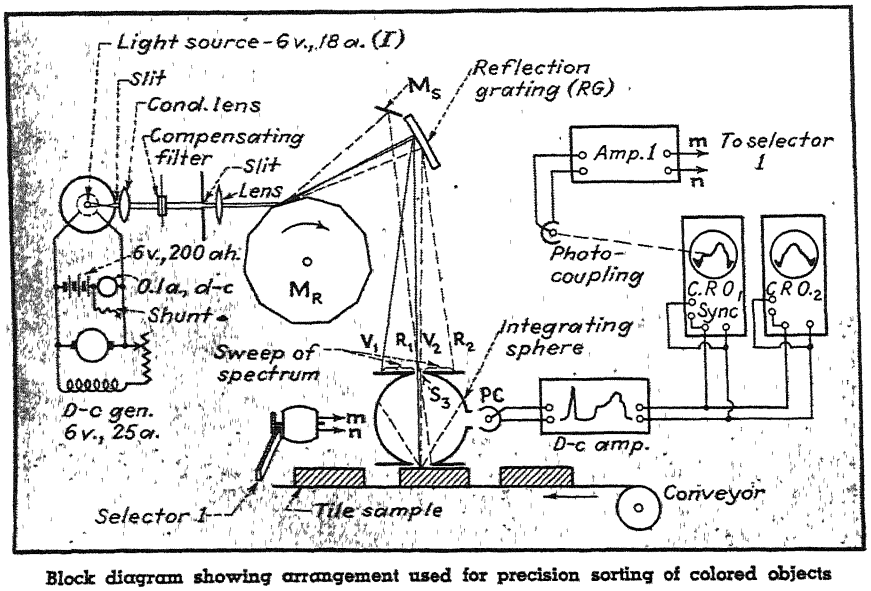
MONOCHROMATIC LIGHT USED—The method used for projecting the different colors of light on each tile sample and producing the spectrophotometric curve on the cathode-ray tube screen for observance by the phototube of the sorting system is shown in an accompanying drawing. Light from a six-volt incandescent lamp is projected onto a rotating polygonal mirror M_R as a ribbon-shaped beam by a system of lenses and slits. Each segment on the rotating mirror wheel causes a narrow band of light to sweep from top to bottom across the reflection grating RG and a stationary mirror M_S. The reflection grating has the property of spreading out white light into a spectrum similar to that obtained from a prism or in a rainbow, and this spectrum sweeps repeatedly across the tile sample through top slit S_3 and the open bottom of the integrating sphere as the mirror wheel rotates. During each sweep period, reasonably pure monochromatic light of each wavelength from violet to red successively irradiates the tile under test while this tile is carried past the open bottom of the sphere by the conveyor belt.

Light reflected upward from the tile illuminates the highly reflecting interior surface of the integrating sphere, and the light reflected in turn from the spherical surface is picked up by phototube PC. Fixed mirror M_S is used simply to direct a momentary flash of white light into the sphere and phototube a short instant of time before the start of a sweep period for colored light; this gives a synchronizing pulse that is used to trigger the horizontal sweep generator and make the electron beam sweep horizontally across the cathode-ray tube at the instant when the phototube starts sending color data to the vertical deflecting plates of the tube during each sweep period.

The output of the phototube is a very weak electrical signal that must be built up in strength by a D.C. ampli-



Examples of spectrophotometric curves for colonial ivory (a) and jonquil yellow (b) samples of enameled porcelain. The photo-electronic sorter can readily distinguish between these two almost identical colors Wavelengths shown are for violet, at left, through blue, green, yellow and orange, to red at the right



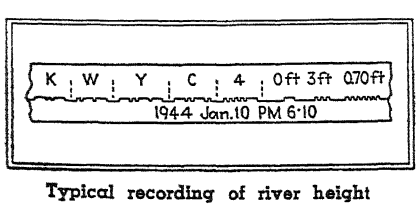
Block diagram showing arrangement used for precision sorting of colored objects

fier before it is fed to the first cathode-ray oscilloscope. The screen of this oscilloscope is provided with a mask designed to cover the allowable variations in color response for the tiles to be selected by the first sorting station. A phototube positioned in front of the screen actuates an amplifier and selecting mechanism that route tiles of the desired color to one bin and route all other tiles to additional sorting stations. Each sorting station contains an oscilloscope, phototube, amplifier, and selecting mechanism, with each oscilloscope screen masked for a different color response. Whenever the moving spot of light moves out from behind the mask on its oscilloscope screen, the corresponding phototube responds to that light and initiates the mechanical action that shoves the tile into its appropriate bin A lever operated by each tile, as it passes beneath the integrating sphere, switches the oscilloscopes on and off to avoid operation in between tiles

MANY USES POSSIBLE—Other kinds of colored objects can be sorted as to shades in exactly the same way. Thus, when uniform color shades are important in women's apparel and colors tend to vary slightly due to variations in dye baths or in dye-absorbing qualities of the textile material, the finished products can well be sorted for precision matching. Women's stockings might be one profitable application, permitting the new advertising appeal of electronically matched pairs. Spools of colored thread, colored pottery vases and ornaments, molded plastic products, oranges, lemons, and other fruit, ceramic dinnerware, colored glass products—in fact, any colored object requiring precision automatic sorting into nearly similar shades can be handled successfully by this new electronic development.

Other testing processes that require almost simultaneous checking of characteristics over a wide range of conditions are logical applications. Thus, curves of special steels for radio and electrical coils and transformers can be checked in production. Hardening operations on steel objects can be checked by passing the object through a coil connected to an amplifier that feeds the oscilloscope; color-sorting equipment would here be unnecessary, as the coil would convert the varying magnetic qualities of the object into a varying electrical signal.

The development of this new cathode-ray and phototube technique for intricate sorting jobs has tremendously broadened the scope of applications for automatic electronic sorting. As with conventional electronic sorting equipment such as that for eliminating black and discolored beans from white beans, the introduction of electronic methods gives a tremendous increase in output with improved efficiency of sorting, no lapses due to fatigue or wandering of the human mind, and reduced inspection or sorting costs.



Typical recording of river height

RIVER LEVEL

Recorded By Radio

Remote Control

INCREASES in the levels of the Salt and Verde Rivers near Phoenix, Arizona, are recorded in a central office in Phoenix by a new radio remote registering system. Gages installed in both streams automatically send radio signals from 25-watt transmitters.

The telemark coder in the transmitter is a combination coding device and time switch, actuated by a float. When the telemark is signalling, a motor-driven contact arm sweeps across ridges on disks attached to the float, to produce signals which represent the gage height of the river at that moment.

Before the contact arm passes over the disks, it travels over a bar having the station's call letter cut into its surface in Morse code. When the arm contacts this surface, the station's identification is transmitted, immediately followed by the gage height.

The time of broadcasts is predetermined and controlled by a time switch. This consists of a weight-driven clock which operates a series of switches that turn the transmitter and telemark on and off every 12 hours below a certain critical gage height, and every hour after that height is reached.

MERCURY SWITCH

Supplemented by Electronic Time-Delay Relay

IN ONE textile plant, cotton is removed from the original bale and then partially cleaned and fluffed up into a loose condition by special machinery. Frequently the cotton being fed into this machine accumulates to such an extent that it overflows from the bin onto the floor, making it necessary for someone to replace it in the feeder hopper.

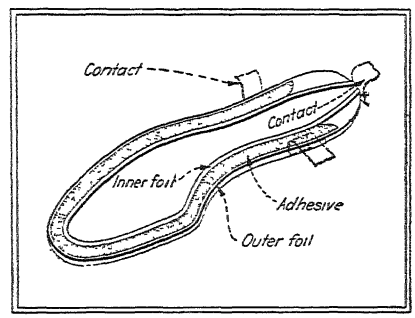
To shut down the feeding machinery automatically, a mercury switch has been used which trips when the cotton in the bin reaches a predetermined level. At this level, however, the moving cotton in the bin constantly trips the switch. This means repeated starting and stopping of the feeding machinery while the bin is full.

Supplementing the mercury switch with a General Electric electronic time-delay relay solved the problem. Once the mercury switch has initiated a shut-down period, the relay keeps the cotton-feeding equipment inoperative for a preselected period of time, irrespective of the opening and closing of the mercury switch. After the time period has elapsed, the mercury switch again takes over to start the feeding equipment

SHOE SOLES

Glued by Electronic Heating Method

A PROCESS of glueing shoe soles by electronic heating consists of attaching to the sole a strip of metal foil running parallel to the inner edge of a band of adhesive and more foil close to the outer margin of the adhesive, preferably upon the periphery of the shoe sole. The two foils thus form capacitor elements which, when connected to a source of high-frequency power, produce electrostatic heating of the adhesive. This quickly sets the glue and secures the sole to the insole of the shoe.



Time saver in shoe manufacture

Invented by G. Hart, Jr. and E. E. Winkley, the method has been adopted by the United Shoe Machinery Corporation, and is expected to save the relatively long period of drying under pressure now necessary in shoe-cementing operations.

MAIL SORTING

Could be Accomplished Electronically With Suitable Preparation

SORTING of mail electronically could be accomplished if a row or rows of black and white squares were used to designate the first main geographical subdivision in addresses. A second row would identify the postal substation and a third row the city postal carrier district. A form of rubber stamp would be used by the sender or at the first post-office to imprint this design on the letter, utilizing a key sheet to prepare the design from the elements of the address to which the letter is to be sent.

Letter envelopes could then be run through a machine that lines up a photographic scanner along the bottom edge of the envelope and, as the letter whisked in front of the electric-eye, it would do the equivalent of reading the address in the coded squares and then automatically route the letter to the correct mail bag or container. This would be repeated again for the second row and again for the third row when the letter arrived in the final postal sub-district. Thus it would have to be looked at only by the carrier.

Safety with Solvents

Many New Industries Are Using New Solvents in New Processes. In Order That Workers May be Protected Against Possible Danger from these Substances, a Number of Agencies are Co-Operating. Standards of Vapor Concentration are Being Set, and Preventive Measures Developed

By H. P. QUADLAND
Safety Research Institute

SEVERAL decades ago, a mere handful of organic solvents were in common industrial use—the benzol and benzine series, some alcohols and esters, acetone, carbon tetrachloride, and a few others Today, it is estimated that there are approximately five thousand such solvents, each with its individual abilities for dissolving industrially important materials.

These chemicals are vital to modern industry. They are especially important in the manufacture of plastics, chemicals, pharmaceuticals, and synthetic rubber; in metal degreasing, electroplating, and other processes, in dry cleaning and in making paints and lacquers, explosives, and textiles—to name only a few of their major fields of use.

Organic solvents belong to the group of industrial substances which, when employed with ignorance or carelessness, may endanger their users. They are, however, being utilized safely in huge quantities in modern industry, but only where safeguards are established to protect workmen. Many millions of dollars have been expended for ventilation and special equipment to ensure their safe use, but there is still a long way to go before all industry shall have completely protected its workers from all of the dangers inherent in the use of solvents. Among the agencies co-operating for this purpose are the manufacturers of solvents and of machinery in which solvents are used, the United States Public Health Service, state and city hygiene services, industrial physicians, safety engineers, and insurance companies.

In the use of the solvents there are three principal hazards—flammability, effect on the skin, and toxicity.

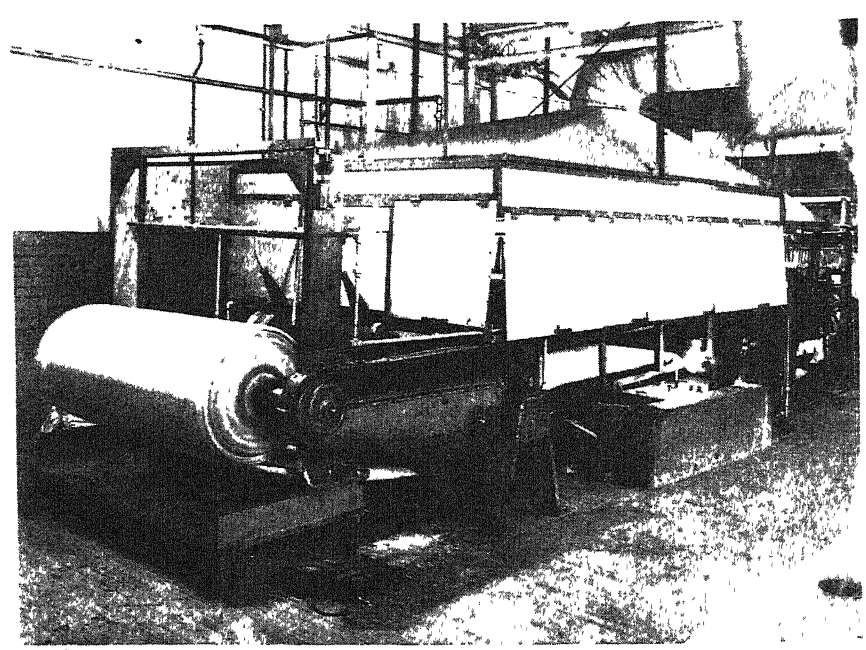
With the exception of certain of the chlorinated solvents, such as carbon tetrachloride, trichlorethylene, and perchlorethylene, which are either completely noncombustible or practically so, most solvents are flammable and explosive. If allowed to collect in the atmosphere their vapors may be ignited by a static spark, a nearby flame, or a careless smoker Gasoline, acetone, and carbon disulphide are typical solvents of high flammability. The National Fire Protection Association estimates that approximately 24,000 fires were caused in 1941 by flammable liquids. [See page 55 for an account of efforts to reduce industrial fires—*Editor.*]

The effects of industrial solvents on the skin depend largely upon the nature of the solvent. Prolonged contact may dissolve the natural oils of the skin, leaving it open to infection, or may sensitize the skin and bring on rashes or other eruptions. Skin manifestations account for nearly 70 percent of the occupational disease claims, but, while they may cause loss of time and discomfort, they seldom result in more serious injury Removal of contact with the solvent is the usual cure. Prevention of dermatoses is accomplished in industry by the enforcement of personal cleanliness and the use of protective clothing and hand creams

The vapors of all organic solvents are injurious if inhaled in excessive quantities for a sufficient length of time The types of exposure to solvent vapors are designated as "acute" and "chronic."

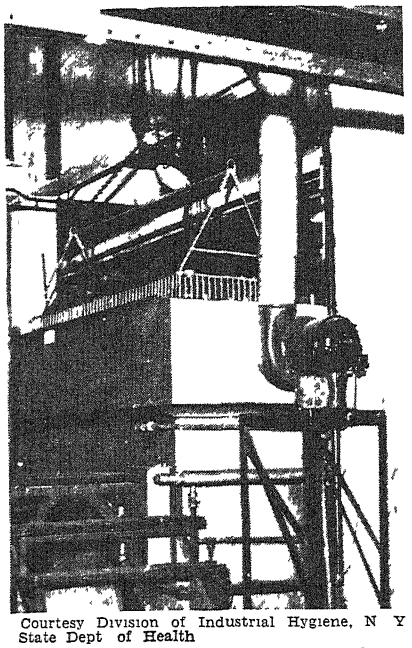
The acute exposure is the result of an accident, or ignorance, by which the exposed person suddenly inhales excessive concentrations of the vapor Depending upon the severity of the exposure, he may suffer headache, unusual fatigue, dizziness, nausea, vomiting, intestinal pain, or other minor symptoms The effect is similar to that of ordinary anesthetics. In acute exposure, inhalation of sufficient quantities of the vapors may cause narcosis without subsequent injury, but, if the exposure is severe enough, injury to bodily functions, depending upon the characteristics of the individual solvent, or even death, may ensue.

ACCUMULATED EFFECTS—Chronic exposure is encountered where the exposed person, due to improper ventilating methods, carelessness, or other reasons, over a long period of time in-



Courtesy Goodyear Tire and Rubber Company

Exhaust hood for removal of toxic vapor from the vicinity of a dip tank used in the rubber industry. In this illustration, the inspection door is partly open, but when the flaps are down the flow of air is from the dip tank to the hood opening. The hood is designed to move 9000 cubic feet per gallon of solvent evaporated



Courtesy Division of Industrial Hygiene, N Y State Dept of Health

Ventilation of an industrial degreasing unit is important. In the equipment shown, the solvent vapors are exhausted through the pipe

hales solvent vapors in concentrations below those which will cause immediate effects, but above those known to be safe. The human body has a capacity for withstanding the effects of certain amounts of solvent vapors but if a greater amount is inhaled day after day than the body has the capacity to eliminate, the effects accumulate little by little until injury results If the person suffering from chronic exposure is detected in time, he generally recovers merely by removal from the exposure, or by medical treatment, or both. However, if the exposure is continued long enough, permanent injury or even death may ensue.

In classifying the toxicity of the different organic solvents, F. Flury, in *Toxicology and Hygiene of Industrial Solvents,* states:

"The only classification is a threefold one, namely, the division into comparatively harmless solvents, solvents with considerable toxic effect, and, finally, strongly toxic substances that are especially dangerous"

Of lowest toxicity, according to Flury's classification, are the majority of the less volatile substances, that is, from the glycol series; among the more readily volatile substances, the solvents of the benzine series, ethyl alcohol, ether, the intermediate acetate esters, and probably also acetone; and among the chlorinated hydrocarbons, dichlormethane, monochlorethylene, and tetrachlorethylene.

In the middle group belong the great majority of the solvents; the amyl compounds; most of the chlorinated solvents, such as chloroform, trichlorethylene and carbon tetrachloride; the benzol homologues, the chlorobenzenes, and the hydrogenated cyclic hydrocarbons.

ESPECIALLY DANGEROUS—The third group consists of the substances distinguished by an especially high toxicity: the methyl compounds, such as methyl alcohol, methyl chloride, dimethyl sulfate; tetra- and pentachlorethane, benzol and carbon disulphide.

Common solvents of high toxicity include the following

Benzene. Commonly called "benzol," this solvent is not to be confused with benzine, a petroleum distillate Severe or chronic exposure to concentrations of vapor above those known to be safe may cause hemorrhages and marked but varied changes in the blood picture, such as anemia, leukopenia, and so on Injury may occur to blood vessels, heart, liver, kidneys, and nervous system, with a marked susceptibility to infection and local irritation Benzene is also highly flammable and explosive

Carbon disulphide. In addition to the effects common to early exposure for all solvents, physical effects, such as hilarity, agitation, and hallucinations may be caused by severe exposure. Disturbances of sensation, particularly of sight, polyneuritis, and so on may also occur. Carbon disulphide, also, is a highly explosive and flammable liquid.

Methyl alcohol. Commonly known as "wood alcohol," or "methanol," this substance, in severe exposures, may cause colic, convulsions, cyanosis, loss of reflexes, irregular heart action, and rapid breathing followed by marked drop in temperature. Methyl alcohol has a specific effect upon the optic nerve and can cause optic atrophy and blindness, thus resulting in permanent injury. It is flammable and explosive

Tetrachlorethane. This solvent is not to be confused with tetrachlorethylene, which is of lesser toxicity. Severe exposure may cause injury to the liver, jaundice, albuminuria, and slight anemia. Tetrachlorethane is completely nonflammable and nonexplosive.

Permanent disability is rare with exposure to the vapors of common solvents of medium toxicity. Cessation of the exposure and proper treatment usually lead to full recovery. This group includes·

Carbon tetrachloride. In severe exposure to this solvent, serious damage to the liver and kidneys may occur. Carbon tetrachloride is completely nonflammable and nonexplosive.

Ethylene dichloride In severe exposure, it may damage the liver and kidneys. It is flammable and explosive.

Tetrachlorethylene (perchlorethylene). In severe exposure, liver and kidneys may be affected It is completely nonflammable and nonexplosive.

Toluene (toluol), and xylene. These substances are similar to benzene in their effect upon the bodily organs, but, because of their higher boiling points, their vapors are not so readily volatilized. However, in recent animal experiments, considerable renal irritation from exposure to toluene was found. As with benzene, severe exposure may cause varied changes in the blood picture. Both toluene and xylene are flammable and explosive.

Trichlorethylene. Severe exposure may result in injury to the trigeminal and optic nerves and to the central nervous system. Irritation of the respiratory passages has also been reported. Trichlorethylene is nonflammable and nonexplosive at ordinary temperatures, but may form flammable mixtures with air at elevated temperatures under certain conditions.

Turpentine. In severe exposure, it irritates the upper air passages, with cough and bronchial inflammation, and may cause pre-disposition to pneumonia. It may also cause kidney and bladder irritation It is flammable and explosive.

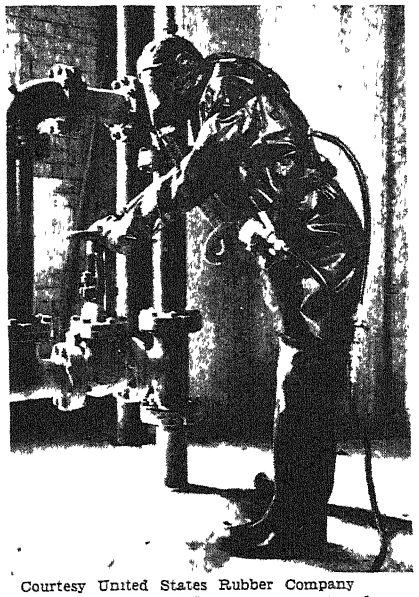
Among common solvents of low toxicity are included·

Acetone. The symptoms of more severe exposure are irritation of eyes and respiratory tract. It is a highly flammable and explosive solvent

Petroleum solvents. These solvents include naphthas, gasoline or benzine, and solvents of the kerosene class, such as Stoddard's Solvent Severe exposure may cause loss of weight, anemia, yellow atrophy of the liver, and jaundice Dr. W F. von Oettingen, Principal Industrial Toxicologist for the United States Public Health Service, points out that appraisal of these solvents offers considerable difficulties because most of them represent heterogeneous mixtures and their composition is often incompletely known. However, the greater hazard in connection with the petroleum solvents is their flammable and explosive properties and this constitutes their chief problem in industry.

Amyl acetate. This substance may cause irritation of the mucous membranes, oppression in the chest, and cough It does not appear to cause more severe symptoms, although some persons cannot tolerate the odor. Amyl acetate is a flammable and explosive substance

Ethyl alcohol. When continuously inhaled in concentrations above those



Courtesy United States Rubber Company

When a breakdown occurs in the piping system of the alkylation section of a high-octane gasoline plant, repair men must be protected against the resulting fumes. One plant uses this type of protective coverall, topped off by a respirator. Air lines already installed in the plant provide air for breathing and also give a constant exhaust flow of air from the suit to keep out the deadly fumes

known to be safe, it may act on the nervous system, or cause narcosis, as with solvents generally. However, the principal hazard of ethyl alcohol as used in industry is its flammable and explosive nature.

INDIVIDUAL SUSCEPTIBILTY—Some persons are more susceptible to solvent vapors than others. It is generally recommended that persons suffering from alcoholism, diabetes, anemia, kidney or liver troubles, and similar disorders should not be allowed to work where there may be potential exposure to solvent vapors. Also, some persons are unusually sensitive, either physically or psychologically, to concentrations of solvent vapors that have no effect on normal persons. Some individuals are nauseated simply by the smell of certain paints, gasoline, amyl acetate (banana oil), or other chemicals. Lowering of the concentration of vapor in the workroom atmosphere may benefit unusually susceptible people, but the more common practice is to assign them to other work.

Skin troubles, too, depend to some extent upon individual susceptibility, although a certain degree of immunity is usually developed, provided protective clothing and personal cleanliness are the rule.

The pre-placement medical examination is important, to avoid placing workers in positions for which their physical or psychic condition is unfitted.

Control of the health factors usually consist of the following:

1. A study of the solvent to be controlled, as to its physical properties and the nature of its toxicity, on the basis of information from the manufacturer of the solvent, federal and state hygiene services, private consultants, or through chemical analysis by the user.

2. A job analysis of the operation in which the solvent is to be used, including a study of operator technique. Certain operator techniques are often adopted that minimize the possibility of contact or vapor inhalation.

3. Development of ventilation, usually local exhaust, which removes the vapors at their source, before hazardous amounts enter the breathing zone of the workmen. Completely enclosed machines are used in many processes, and these are generally preferred, since they provide full safety where the instructions issued by their manufacturers are observed. Where there is any possibility of unsafe quantities of vapors in the atmosphere, periodic air sampling to determine the actual concentration is a matter of course in modern plants.

4 In cleaning tanks and similar operations of an intermittent nature where temporary exposure to high concentration of vapor is involved, air-line respirators and full protective clothing, with a watcher outside the tank, are required. In intermittent operations where, for brief periods, the concentration of vapor is slightly above the safe maximum allowable concentration, organic vapor type masks approved by the United States Bureau of Mines are sometimes used.

5. Especially in the larger plants, medical control supplements engineering control If early symptoms of exposure to solvent vapors occur, immediate examinations are in order and remedial measures are provided before there is injury.

Where flammable liquids are employed as solvents,, the following rules are generally observed:

1. All fires, flames, and high temperatures in the vicinity are eliminated. Non-sparking shoes are provided, as well as safety containers for the solvent. The National Fire Protection Association code for handling flammable liquids is observed.

2. Electrical equipment, including vapor-proof safety lamps, is installed in accordance with the National Electrical Code for hazardous locations.

3. Equipment, including funnels and portable containers, is grounded when in use, to prevent ignition from static electricity.

4. Ample ventilation is provided to keep the concentration of flammable vapors well below their explosive limits in all locations, including low places such as shafts, pits, basements, and so on.

5. Adequate fire protection equipment of the correct types is provided and workers are trained in its use.

ALLOWABLE CONCENTRATIONS—In recent years, through the machinery provided by the American Standards Association, manufacturers of solvents, public health authorities, and insurance companies have been co-operating to develop national industrial standards for a number of the more common solvents. These standards establish, in terms of "maximum allowable concentrations," the maximum amounts of solvent vapors in the workroom atmosphere to which workers may be exposed throughout the working day. A.S.A. standards have been established for methyl alcohol, toluene, xylene, benzol, and carbon disulphide. Standards for carbon tetrachlorides and trichlorethylene are now in progress.

In addition to the standards set up by the A.S.A., the United States Public Health Service has listed the most widely accepted maximum concentrations, for an eight-hour working day, for amyl acetate, butyl acetate, butyl alcohol, carbon tetrachloride, ethylene dichloride, gasoline and petroleum naphthas, monochlorobenzene, nitrobenzene, tetrachlorethane, tetrachlorethylene (perchlorethylene), trichlorethylene, and turpentine.

Some states have set up their own standards, which must, of course, be observed in those states.

The method of control must be as simple as possible, yet provide effective protection. With some processes, however, the method is necessarily complex, as in the case of the synthetic rubber and similar large industries, where controls are carefully designed by competent industrial hygiene and fire protection engineers.

In all safety work, including the safe use of solvents, the human factor plays a leading role. Elaborate machinery and ventilating devices to assure safety are of little avail where operators do not use them to advantage.

A case in point is that of a foreman of a crew painting the inside of a tank car with an acid-resistant paint containing a solvent. The foreman provided his crew with all the protective apparatus required by the company to assure complete protection from the solvent vapors. They had air-line respiratory equipment, protective clothing, a rope down into the tank car, and men outside to pull out anyone who might be affected in the slightest by the vapors After seeing that his men were protected beyond all possibility of injury, the foreman himself walked down into the tank without any protective equipment and died before they could get him out.

In addition to providing the proper engineering controls, education of workers is necessary to assure safe use Not only the operators of the processes, but janitors and maintenance men as well should be thoroughly instructed

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SKIN CREAMS

Give Protection Under Wet and Dry Conditions

THE NAME Clad has been given to a new line of protective skin creams, made in two types, for dry and for wet working conditions.

The dry cream is of an improved type which has been made as nearly neutral to the skin as possible. These properties eliminate skin drying or any tendency to cause burning or irritation even under prolonged usage. Use of the dry cream protects exposed portions of the body against dirt, grease, grime, and any other hard-to-wash-off substances.

The cream for wet use is made for protection of the skin where water and other dilute aqueous and mild chemical solutions are present.

Both the wet and dry types leave the skin soft and smooth even after the cream is removed. Both have been constantly tested under regular operating conditions.

The dry type cream is finding wide general household usage, in addition to its industrial applications.

Industrialists report that use of protective creams, while not as effective as rubber gloves, greatly assists workers to reduce hazards from dermatitis and reduces "wash-up" time. This is especially true of the newer workers being drafted from the home and the white collar groups into industrial plants, who find it necessary to protect hands and other exposed parts of the body against working conditions

"PLANT INOCULATION"

Bigger Yields Result From New Chemical Soil "Serums"

SPRAYED on the ground and absorbed by food-producing plants to render

(*Please turn to page* 85)

Keep Them Tight

Though the Bolt Designers Most Diligently Design, and the Metallurgists, the Engineers, and Manufacurers do their Utmost to Provide Excellent Bolts, the Bolts that Carry Dynamic, Fluctuating Loads in Severe Service will Fail from Fatigue unless Science is Correctly Applied in Tightening Them

WHICH of two bolts or studs in exactly the same highly-stressed, dynamically loaded, severe service will be the first to fail from fatigue—one whose nut has been set up so tight that the yield point of its metal is closely approached, or one whose nut has been tightened only lightly?

You may try this question on engineers or metallurgists and expect a high percentage of correct answers; or on a shop superintendent or foreman or machinist; or in the office of the same shop (where your answers may perhaps prove somewhat less uniform), or if you should meet with an unexpectedly high engineering I.Q. everywhere else, you may finally have to try it on your long-suffering wife who, even then, would have one chance in two of getting it right merely by guessing. Yet the chances are that a goodly share of all the people you ask will plump for "the bolt that hasn't been set up tighter than Tophet by some big strong lummox with a long-handled wrench. For isn't the bolt's external load enough for it to carry without giving it a big internal load too?"

The correct answer is that, for service such as was specified—that is, for highly stressed, dynamic or stress *changing* service (the italicized word is the crux of the argument)—the bolt that has been set up close to the yield point of its metal and sometimes even past that yield point, will far outlast the one that has apparently been babied. You may argue that every engineer and every good mechanic already knows that fact, yet if they know it, not all of them practice it with conviction equal to their knowledge. Many who "know" it only half believe it

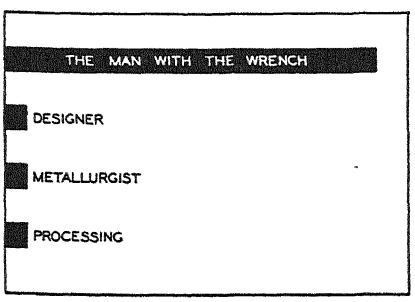


Figure 1: The elevation of the humble to the ranks of the nobility

There will, of course, be no point in asking the above question unless "dynamically loaded" is stipulated In other words—to bring the matter sharply into the clear—for non-dynamic loads, non-changing loads, dead loads, like those, for example, on the king-rod in a wooden roof truss, the two bolts would be on a par. Chose, instead, some such example as the bolts that hold the bearing caps on a reciprocating connecting rod.

A QUESTION OF MOMENT—The importance of bolt tightness has been discussed in detail by J. O. Almen, Head of Mechanical Engineering, Laboratories Division of General Motors. Far from being merely an interesting catch question, the one stated above is of large moment in the whole of industry since

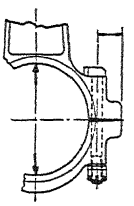


Figure 2: A typical example of a bolt subject to dynamic stress

bolts, next perhaps to welding, are the most widely used fasteners for holding machine parts together against dynamic, live loads.

Many engineers, Almen contends, fail to appreciate the importance of nut tightness; or if they do appreciate it they sometimes specify for a given job the use of torque or tension wrenches designed to assure the correct tension on nuts by means of indicators embodied in them. Yet, according to Almen, who backs up his assertions with reasons, "a good mechanic who has developed wrench 'feel' is more reliable than the most elaborate torque wrench." In fact, he emphasizes as the main point of his thesis, this man with the wrench, far more than the designer of the bolt with all his fine technical analysis—or the metallurgist, or the manufacturer with his most careful processing—is the factor which determines the strength of most of the highly loaded bolts and studs used in machinery. Just how much more is graphically and quantitatively indicated in Figure 1. Therefore, Almen urges, industry should be less concerned with the design details than it now is—and nearly everybody knows how much applied science, and fundamental science too, lies behind the design of so commonplace a thing as a bolt and nut—and should give more attention to the technique of tightening nuts. In fact, in highly loaded bolts and studs the design is rarely found to be so bad, the fabrication practice so poor, or the material so weak as to cause failure in service, providing the nut is correctly tightened against reasonably rigid bearings.

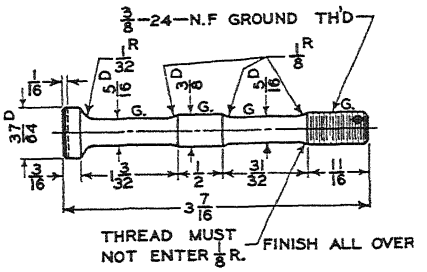


Figure 3: Detail of test bolt

Numerous tests have shown that the fatigue strength of metal decreases as the stress change to which it is subjected is increased; and, conversely, that the fatigue strength is increased as the stress change, or range of dynamic stress, is decreased. As the stress approaches zero, the dynamic load that can be supported approaches the tensile strength of the metal.

Consider as an example the case of the bolt in the connecting rod cap in Figure 2. As the connecting rod reciprocates, this bolt is subjected time after time to a fluctuating load. To make clearer the point of the argument for correct tightening of nuts on such bolts, take three separate and different conditions concerning this bolt.

In the first the nut is tightened just enough to make contact with the bearing caps.

Based on a paper presented before the Society of Automotive Engineers, Detroit.

In the second it is tightened enough to load the bolt to one half of the load caused by the tension due to inertia of the connecting rod and piston as their direction of travel is reversed.

In the third the nut is tightened against reasonably rigid abutments to produce a tension in the bolt equal to or even greater than the load just described.

What now will be the effect in each instance?

In the first instance—that of the nut barely tightened—the strength of the bolt will be less than one fifth of what it would be under a static or dead load.

In the second—the nut tightened to take up half of the external load—the strength may reach one third to one half the static strength.

In the third—the nut tightened enough to produce bolt tension at least equal to working load—the bolt's dynamic strength will approach its static strength.

The underlying reason is that, when the tension produced in the bolt by tightening the nut against reasonably rigid abutments equals or exceeds the working tension load, there will be practically no change of stress in the bolt at any time. In such circumstances the metal of the bolt will not fail from fatigue.

These effects on bolt strength are not merely theoretical; General Motors laboratories ran a series of fatigue tests on 50 bolts, each dimensioned as shown in Figure 3 (where the bolt is shown relieved to the same depth as the root diameter of the thread). The 50 bolts were divided into four groups, respectively of 17, 16, 15, and 2 bolts.

All the bolts were subjected to the same maximum external load, 9215 pounds.

In Group 1 each bolt was tightened to a tension of 1420 pounds, in Group

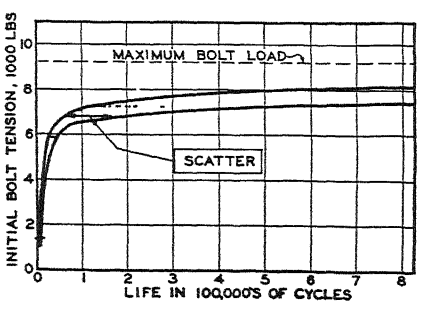


Figure 4: The effect of initial tightness on the life of bolts

2 to 5920 pounds, in Group 3 to 7220 pounds, and in Group 4 to 8420 pounds—corresponding respectively to 15, 64, 78½, and approximately 91 percent of the 9215-pound maximum load applied to the bolt by the fatigue testing machine.

WAY OUT OF PROPORTION—The results were far, far out of direct proportion to the bolt tension figures.

In Group 1, where only 15 percent of the external load was taken up by nut tightening, leaving a net load change of 85 percent to get in its evil work of fatiguing the metal, the fatigue durability of the bolts proved to average only 5960 cycles. That is, after that number of successive applications and removals of load the bolt broke.

In Group 2, where 64 percent of the load external to the bolt was counteracted by tension within it, produced by the tightened nut, the bolt lasted 35,900 cycles.

In Group 3, where the nut was tightened enough to account for 78½ percent of the external load, 214,500 cycles of stress change were run off before the bolt failed from metal fatigue.

Finally, when 91 percent of the load applied by the testing machine was balanced by internal tension of the bolt, one of the two bolts tested stood up for 4,654,000 cycles and the other to 10,000,000 cycles, at which point the test was stopped.

The same data look even more impressive in the form of Table I.

In graphical form, Figure 4 tells the same story but the scale of the layout prevents inclusion of the fourth group of bolts which, if shown, would be plotted about one foot to the right of the graph, but almost no higher than the end of the curves as now shown. The two curves of this figure show the variation ("scatter") in durability between the individual bolts in each of the groups tested; naturally, not all bolts are exactly alike.

Why not, then give the bolt an even higher tension, before applying the external load to it, than that load will be? Nothing looks simpler, but it won't work even if you plan it that way. Obviously, if it would work, that is what would be done and the whole matter easily ended.

When the nut is insufficiently tightened, each load application will elastically elongate the bolt, and a gap will be formed between the bolted members. The magnitude of that gap will be reduced as the nut tightness is increased. When the nut tightness is brought near the operating load, this gap will not occur. Nevertheless, there will be a small elastic elongation of the bolt. But when the bolt is tightened and thus elongated, the abutments against which it bears are elastically shortened. When the external or operating load is put on the bolt, the bolt is acted upon by that load plus the load of elastic recovery of the bolted assembly. The sum of these forces will always be greater than the tension given the bolt by the nut.

Therefore, no matter how hard you try to catch up with the external load by tightening the nut, you can't reach your goal, and the bolt will therefore undergo a change of stress at each application of external load. But that change of stress will be reduced in magnitude as the rigidity of the bolted assembly is increased by tightening the nut. Both the recent tests described, also a century of empirical practice before the subject was made the object of scientific investigation, bear out this fact Thus, when the load change is reduced to small proportions the fatigue strength of a bolt approaches the life of the assembly of which it is a part.

The graph, Figure 5, relates to another aspect of the subject of bolt

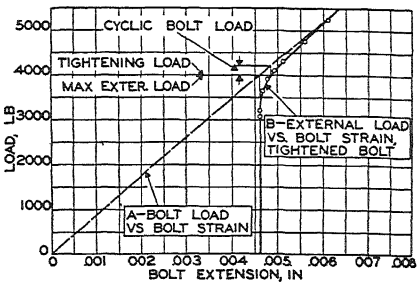


Figure 5: A typical plot for the determination of bolt cyclic load

tension—the determination of cyclic bolt load.

STRESS-STRAIN MEASUREMENTS—As a preliminary to the fatigue testing of the 50 bolts, stress-strain measurements were made for each bolt, using facilities which the testing machine employed affords for accurately weighing the load applied to the specimen at any position of the load-applying device In Figure 5 the long inclined "curve" (which happens to be straight) is the load extension curve of the bolt alone —so much load put on the bolt by the nut, so much extension of the bolt The second curve, *B*, on the same graph, contains several plotted points which were taken from a bolt that had been tightened against relatively rigid abutments to a load of 4000 pounds Under that load the bolt elongated in the tests, as the vertical part of the graph shows, 0.0046 inch. As the external load was applied to this already tightened bolt, the external load extension curve *B*, as revealed by the plotted points, did not rise vertically to join the curve of the bolt alone—that is, curve *A*—as would be the case under ideal conditions of an elastic bolt and perfectly rigid abutments. The plotted points *B* join the vertical line at 0.0046 inches elongation and the inclined line *A* by an easy curve. This shows that the bolted members are elastic, and that the load on the bolt is augmented by the elastic recovery of the bolted members.

What of the effect of this elastic recovery? The added load increment due to the elasticity of the bolted members can be measured direct from the curves. For a special case in which the external load is equal to the initial bolt tension, the horizontal 4000-pound

TABLE I

Initial Tension (Nut)	Operating Load	Load Change	Stress Range	Average Life
1420 pounds	0 to 9215 pounds	8000 pounds	.85	5,950 cycles
5920 pounds	0 to 9215 pounds	3300 pounds	.36	35,900 cycles
7220 pounds	0 to 9215 pounds	2000 pounds	.215	214,500 cycles
8420 pounds	0 to 9215 pounds	800 pounds	.087	5,000,000 cycles+

line representing the initial load due to the nut is extended to the right till it intersects the curve of the several plotted points. This will be found to lie at a bolt extension of 0 00485 inch. Now, since the extension under the preload (nut load) was 0.0046 inch, the bolt elongation has increased 0 00025 inch; that is, the difference between the two figures. Now the new line on that figure—namely, 0 00485 inch—is projected vertically to intersect the long inclined curve *A*. This will correspond to a load of 4220 pounds, or a load increase of 220 pounds over the initial 4000-pound bolt tension

The load range experienced by the bolt under these conditions would be $1 - \frac{4000}{4200}$ or 0 052. This is so small a stress range as to be practically zero, and thus the bolt load is therefore almost static.

In the same manner e resultant bolt load may be found fc ny external load, whether greater oi ss than the internal load.

Other evidence, too c iled for the space available here, le: to the conclusion that the materia n a machine assembly, and its desi have large influence on bolt streng Even if the nut is correctly tighten the bolt will be weaker when used, for example, in combination with aluminum abutments than with steel This is because of the greater elastic deformation of aluminum. Similarly, if the abutments are of small area the bolt will be weaker. Similarly, too, the more parts the bolted assembly contains the weaker will be the bolt, because mating parts never fit perfectly.

ARRANGEMENT AFFECTS BOLT STRENGTH—Another fundamental principle, related closely to the one just described, and set forth by Almen, is shown in abstract form in Figure 6 and in application to everyday realities in Figure 7, which represents two elastically deformed plates and a gasket, also two plates in a bolt and spring washer assembly.

The fundamental which Figure 6 rather abstractly illustrates—since such a set-up will not often be found in an actual mechanism—is that the arrangement, good or bad, of the parts in a

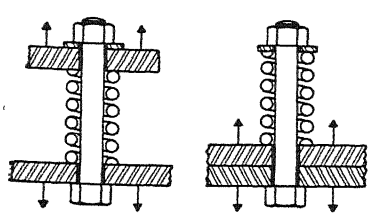


Figure 6: In first drawing, bolt is weak, in the second strong. Why?

bolted assembly can exert enormous effect on bolt strength. Both of the assemblies in Figure 6 may be seen to contain identical parts. In both, the external load (arrows) is applied against the bolt by the two stiff plates. But in the first the bolt will be weak and in the second the same bolt will be strong. Why?

The reason is that, in the first bolt, when an external load equal to the internal load—that of the bolt's tension caused by the spring—is applied, the total load on the bolt will be twice that tension· once for the spring and once for the external load. The stress range experienced by this bolt will therefore be 1 — ½, or 0.5. If this magnitude of

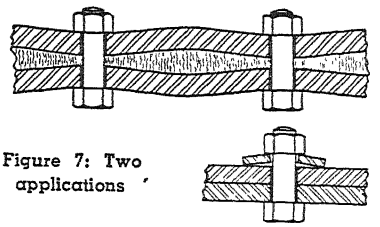


Figure 7: Two applications

stress range is now compared with the figures in the stress range column in the table it will be found that it is similar to the stress ranges of bolts that failed relatively early. Thus, in this set-up, the bolt is weak

In the second set-up the bolt is strong, as already stated. Just what, then, is the essential difference between the two arrangements, so far as the bolt is concerned? In the second set-up the spring, which formerly was a part of the abutments, is now a part of the bolt; hence, now a very elastic bolt (elastic because of the part of it which consists of a spring) is tightened against relatively rigid members, the plates. When an external load, equal to the tension of the spring, is applied to the plates, the load between the plates is reduced to zero, but the bolt still has its original load—that of the spring—and there now is no stress range. Hence the bolt rates as static and failure from fatigue cannot occur, no matter how many times the stress is applied to the plates.

Now for the practical applications of these principles

Figure 7, top, represents a condition often met with in practice, a gasket clamped between two mating plates. The gasket is compressed locally near the bolts, and the plates are bent until they act like the spring in the first set-up of Figure 6. When, in addition to this initial load, the external load tending to separate the plates is applied, the bolt will feel both loads. Usually, also, such bolts are short and therefore they have small elastic elongation. Thus in this kind of arrangement the stress range will be large and this will be an invitation to failure from metal fatigue.

REMEDY—The remedy offered by Almen consists of minimizing the spring-like bending of the bolted surfaces by allowing large gasket area near the bolt, and relatively smaller area in proportion to distance from the bolt, also in making the gasket as inelastic as possible, in order not to let the bolt down.

The lower part of Figure 7 shows one way to increase bolt life. The spring washer increases the effective elasticity of the short bolt, and thus the fatigue strength of the bolt is increased. This arrangement corresponds to the right-hand sketch in Figure 6, in which the spring is a part of the bolt and the bolt is strong Any other expedient that will increase the rigidity of the bolted assembly will increase the fatigue strength of the bolt.

Bolt tightness must not only be provided but must also be maintained during service. A bolt or stud that is incapable of permanently maintaining a tension equal to the external tension load is likely to fail in severe service The bolt must be able to take up the external load and still be tight Thus, because of their greater elastic yield, there is a higher mortality among short bolts and studs than among long ones For example.

An engine cylinder is attached to a crankcase with short studs, the thickness of the cylinder flange plus the washer being often less than half an inch. If now the elastic elongation of the stud is 0 002 inch, and during operation such factors as wear, corrosion, embedding, or displacement of material such as soft plating, reduce the bolted assembly by only half that much, the stud will lose half of its required tension Fatigue failure will follow.

In a case like the one just described, if a longer stud can be used, greater safety will be assured; the loss of stud tension due to elastic elongation will thus be considerably reduced.

At least one manufacturer tightens connecting-rod bolts actually past the yield point This is far better than to risk undertightness—at least provided

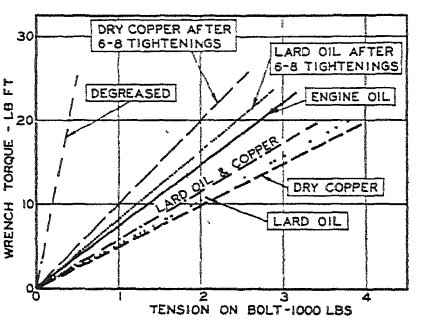


Figure 8: The effect of lubricants on bolt tension upsets precautions

correct caution is used and other factors too detailed to be presented here are considered.

Mention was made of the torque wrench, and the statement by Almen, that a good mechanic who has developed wrench "feel" is more reliable that the best of such wrenches, was cited. His explanation of this is that friction between the threads of the bolt and the nut is so variable that, even with such wrenches, supposedly giving automatically the same tension to every bolt because of controlled nut tightening, bolt tension will vary over wide limits—as much as 10 to 1 in extreme cases.

Figure 8 exhibits this graphically; it is simply a matter of varying coefficients of friction. In actual practice this variation will run between 3 to 1 and 2 to 1, but even this is too wide a spread for so critical an operation as pre-loading severely stressed bolts. It would mean much to industry, Almen urges, if this variability of nut friction could be reduced, thus admitting use of the torque wrench as an accurate tool.

Safety In The Air

In the Science of Biomechanics, Combining the Knowledge of Surgeons and Engineers, is to be Found at Least a Part of the Answer to Fatal Aircraft Accidents. An Understanding of the Strengths and Weaknesses of the Human Body can Aid Aircraft Designers in Building Safer Ships

WHILE safety in civil flying has increased enormously since the early days and is now satisfactory on the airlines, it is not comparable in private operation to the safety of the automobile In 1941, for example, there were approximately 164 fatalities for each 10,000 privately owned aircraft, against eight fatalities for each 10,000 automobiles similarly owned.

In the problem of airplane safety, there is no one great invention which can bring a complete solution; there are many causes and many remedies Spins and stalls predominate in fatal air accidents, but can be reduced to a minimum. Accidents sometimes occur where airplane collides with airplane, but radar will undoubtedly give birth to collision indicators Accidents occur when a pilot shows off in a series of acrobatic maneuvers over the house tops. Training, punishment, and social reprimand are in order here

NATURAL HAZARDS OVERCOME — Weather service is now excellent but the pilot must be made to understand that he cannot venture forth in the face of adverse weather reports. Fog and low visibility are real hazards, but radar, television, and blind landing systems at airports and airfields can make even the worst fog innocuous.

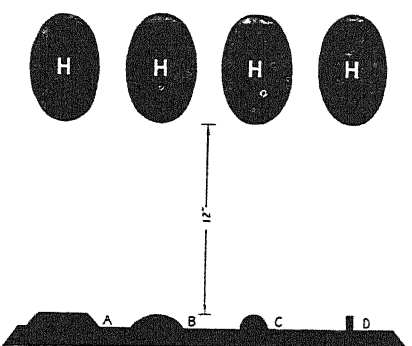
Structural failures have fortunately become very rare in modern designs, though poor maintenance may indirectly cause structural failures. In the power plant, progress has been made by better fuels, greater reliability of the engine itself, provision against carburetor icing, and so on. Recently there have come such aids to safety as the tricycle or nose wheel landing gear which prevents the machine from nosing over on landing, and eliminates "ground looping" when landing in a cross wind.

But mere consideration of these and other devices for safety indicates that, owing to the variety of causes, air accidents will never be wholly eliminated any more than they have for the motor car.

The next thought is, therefore: How can crashes be made to give the fewest fatalities? The answer is that airplane design and the science of biomechanics are now being so correlated that even bad crashes are no longer necessarily fatal.

Dr. Charles Murray Gratz, a surgeon who has made many contributions to this new field of science, writing in *Mechanical Engineering*, describes biomechanics in a few words as follows

"Successful co-operation between surgeons and engineers leads to an exchange of techniques known as biomechanics. Biomechanics is a division of the larger field of biological engineering The term was used in describing the original mechanical heart. Our Russian allies have successfully coordinated surgical and engineering studies. Their perfection of the artificial heart, successfully used in the revival of dogs for periods up to 15 minutes after cessation of circulation, has received due recognition. Surgeons have also used engineering methods to determine the elastic properties of human fibrous tissues, which compare favorably with many structural materials. Shear in human tissues is one of the most important variables in surgery and the biochemical study of shear has greatly reduced the percentage of complication in certain branches of surgery."



Courtesy American Society of Mechanical Engineers

Figure 1: To illustrate pressures when head strikes various surfaces

This co-operation between the engineer and the surgeon is now carrying over into aviation, with the airplane and its human cargo being considered as a unit. As a result, loss of life in crash landings is being steadily reduced and the defenses of the human body are being coordinated with the structure of the airplane and the layout of the cockpit.

A more detailed study of biomechanics as related to airplane safety is to be found in the writings of a research worker in physiology, Hugh De Haven of the Cornell University Medical School. Mr. De Haven has published in *Aero Digest* an illuminating article on the cause of injuries in lightplane accidents.

There is one most important observation in De Haven's studies. In the same crash, one man may escape with minor injuries while another is killed instantaneously. Back in 1908, Lieutenant Selfridge, the first American army officer to lose his life in an airplane accident, was killed at Fort Meyer in an early Wright biplane. The aircraft plunged almost vertically downward from a height of 75 feet. Lieutenant Selfridge's skull was fractured by a blow against one of the wooden uprights of the framework, while Orville Wright, who was flying with him, suffered painful but not dangerous injuries. Such unequal chances of survival in crashes have been noted again and again.

Another observation is that the human body can survive almost miraculously in crashes which far exceed the present strength of aircraft structure. A 1943 accident analysis made by the Safety Bureau of the Civil Aeronautics Board showed that 77 percent of the aircraft involved in spin-stall accidents were rated as "washouts" and 19 percent were so damaged as to require a complete overhaul. Yet only 47 percent of the spin-stall accidents were fatal. How is it that pilots can so often walk away from washout crashes in which survival seems impossible? The answer lies in the fact that the human body is tough, that fatalities often result only from faulty structural and seating arrangements, and that good structural, seating, and instrument arrangements give a chance of survival even in a terrible wreck.

ACCIDENT ANALYSES—Fortunately the Civil Aeronautics Board has analyzed a number of lightplane accidents as a preliminary to remedial design.

One bad contributing factor is found in the egg-shell structure of the semi-monocoque, plastic-plywood structure. If safety is a major consideration, fuselages must be more rugged, possibly reverting to metal or turning to

a better reinforced plastic, which should be resilient and hold together in case of crash.

Another important moral of biomechanics is that shoulder harness, as used in military aircraft, is the most effective defense against injury of the head, spine, and chest. Shoulder harness cannot be used on civilian airliners because of its psychological effect, but even the lap type belt can be an effective safety measure, especially if coupled with better arrangement of the structure and more headroom.

Apparently, serious injuries from the action of the safety belt on the abdomen are few. The abdomen can withstand the violent action of the safety belt and survive, the momentum of the body can be readily checked at the hips and, what is more, the spine itself can stand extreme forward flexion. Structural elements and instrument panels are the factors that cause injuries to the head and chest when the body is held at the hips and thrown violently forward. Here, then, is an important consideration for aircraft designers.

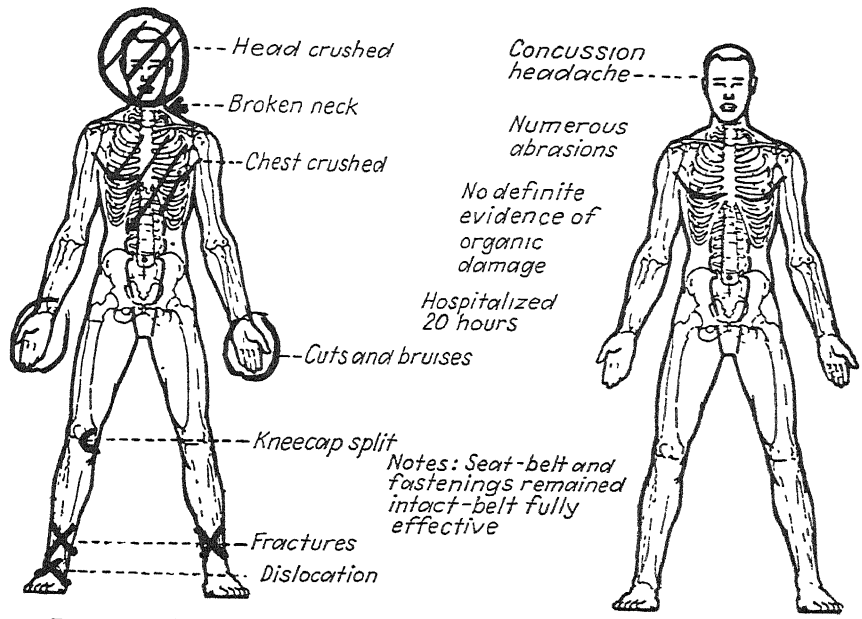


Figure 4: Difference in injuries sustained by two men in same airplane accident

DEATH CAUSES—Under ideal conditions, a human being can withstand decelerations as high as 100 times those of gravity. A car can be stopped from a speed of 50 miles an hour in a distance of six inches without killing the occupants. On the other hand, death can follow an automobile accident at 15 miles an hour if head or body strikes a hard, sharp, unyielding obstruction The diagram in Figure 1 emphasizes this point. Here *H* represents a human head, which weighs about 10 pounds. The distance between the body and the ground is taken to be 12 inches. If the head drops and strikes the flat surface *A*, the pressure on the distributed area would be 480 pounds per square centimeter. If it strikes the convex surface *B*, the pressure becomes 960 pounds per square centimeter, and if the unfortunate human head should strike the steel projection shown at *D*, the average pressure would become 2800 pounds per square centimeter, so that in this instance the chance of survival would be nil!

Accident analysis and theoretical calculations of the above type both indicate, then, that aircraft designers should avoid projecting compass cases, hard control knobs, steel tubes, and the like in regions likely to be struck by the face or head.

Figure 2 gives an interesting example of the importance of seat location. After the accident which this photograph illustrates, the passenger in the rear seat walked away from the scene. The pilot in the front seat was instantly killed by a frontal fracture of the skull; the diagonal brace of heavy tube steel was struck and dented by the impact of his head.

Figure 3 shows an accident of equal severity but more happy results. The pilot's head struck and dented the instrument panel. But there was no sharp projection to injure him and no heavy structural members behind the panel to prevent it from yielding

Another example of the differing hazards of seat position is found in an accident in which the airplane stalled at a height of 100 feet and struck the ground almost vertically. The man in the front seat was killed instantly. The somewhat gruesome labels in Figure 4 explain the different fates that awaited the two men. In the rear seat the full force was taken by the safety belt, the head missed deadly obstructions, and hence no fractures or internal injuries followed. The man in the front seat received the full force of the accident; his head was crushed, his neck was broken, and his chest crushed.

SURVIVAL IN FALLS—In "War Medicine," another paper by Mr. De Haven deals with the subject of falls from heights of 50 to 150 feet. Mr. De Haven

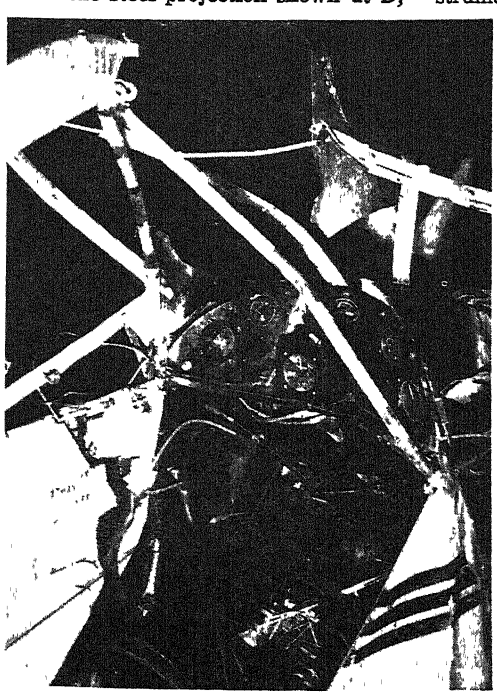


Figure 2, left: A fatality was recorded in an airplane accident when the pilot's head struck the diagonal brace shown, bending it and fracturing his skull. The passenger in rear was uninjured

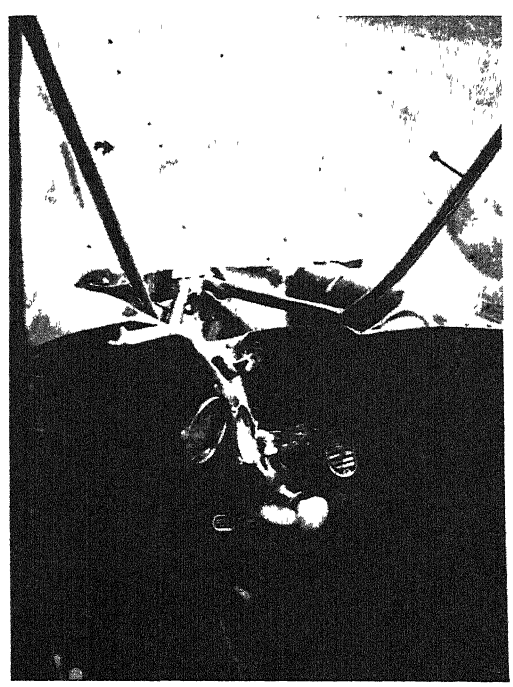


Figure 3, right: The instrument panel in this accident yielded when struck by the pilot's head, and he survived the severe crash

cites some extraordinary examples of survival. Here is one: "A woman, aged 36, 5 feet 4 inches tall, and weighing an estimated 115 pounds, jumped from an eighth floor and fell 72 feet onto a fence, face downward Velocity at contact was 65 feet per second or 44 miles per hour. There was no evidence of material injury. The victim was seen during the fall and landed 'jack-knifed' over the fence, which was constructed of wood and wire. The fence was broken down part way and the victim tumbled to the ground. She immediately picked herself up and walked to a nearby clinic for first aid."

From the reports of this and similar accidents, the author draws the conclusion that the human body can tolerate and expend a force as great as 200 times the force of gravity for brief intervals during which the force acts transversely to the long axis of the body. What is of even greater interest is this statement: "It is reasonable to assume that structural provisions to reduce impact and distribute pressure can enhance survival and modify injury within wide limits in aircraft and automobile accidents."

The main conclusion to be drawn from this combined work of the biomechanic, the surgeon, and the accident investigator is that a serious crash need not be necessarily fatal. The airplane designer has been prone to assume that if a bad crash did occur, there was nothing to be done about it. The occupants would be killed anyway.

CONCLUSIONS EMERGE—This defeatist attitude should disappear as certain conclusions emerge from the study of biomechanics.

Everything possible should be done to avoid crashes, but there is more to be done by designers in lessening the chance of fatal injury in really bad crashes; the airplane designer should take an interest in biomechanics and should study accident analyses. The safety belt does not injure the abdomen and, provided it is solidly anchored, is a valuable safety device, but its greatest benefit can be reaped only after redesign of the cockpit. The instrument panel must offer no knobs or projections or sharp corners to hit the pilot in the head, face, or chest. The instrument panel should "give" on impact and should not be backed up by too rigid a structure. Finally, ahead of pilot or passenger there should be no clusters of dangerous and unyielding steel tubes.

All these are simple, commonsense measures, much easier to understand and apply than the formidable title of biomechanics would seem to indicate. It is gratifying to know that the American Society of Mechanical Engineers is doing much to bring the sciences of biomechanics and airplane design closely together

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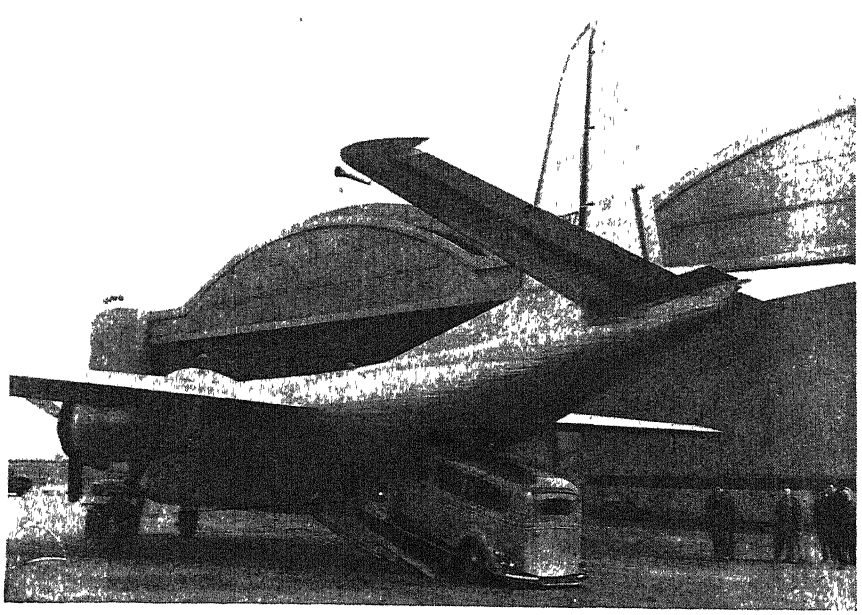
A FLYING FREIGHT CAR

Built of Stainless Steel, Has Huge Cargo Capacity

UNDER Navy auspices, the Edward G Budd Manufacturing Company has built a most interesting cargo plane, for whose design their Chief Engineer, Dr. Michael Watter, has been mainly responsible The new plane is of especial interest for a number of reasons. It is, to begin with, one of the few American aircraft built completely of stainless steel, a material which can be spot welded (thus eliminating the rivet) and which withstands corrosion. Another feature of interest is that the engineers had a single purpose and concentrated on a flying freight car which would carry cargo economically on flights of moderate length and would also permit loading and unloading cargo with ease and speed



The rear of today's "Conestoga wagon" is designed for easy loading

The plane, known as the *Conestoga*, is a twin-engined machine, 68 feet long, with a wing spread of 100 feet, capable of transporting 10,400 pounds of cargo over a range of 650 miles. Each of its 14-cylinder radial air-cooled engines delivers 1200 horsepower for take-off and has a normal rating of 1050 horsepower. Tests show that the plane can take off from a landing strip only 920 feet long.

The main interest in the *Conestoga* lies in the special cargo features. Because of the width of the fuselage and the way in which the rear is swept upward, the plane itself could be designed to carry a ramp at the rear to facilitate loading and discharge. The cargo compartment is 25 feet long, 8 feet wide, and 8 feet high and is wholly unobstructed by structural members Another interesting development is that all loading is done on the level. On the ground and in the air the floor of the cargo compartment remains horizontal An enormous cargo space has been made possible by the method of attachment of wing to fuselage. The wing structure does not pass through the fuselage in conventional form, but is attached to five special side frames joined across the body by shallow but rigid transverse members.

In spite of its size and loading capacity, the plane requires a crew of only two, a pilot and a co-pilot, provided with dual controls. Cruising speed is said to be around 165 miles an hour.

"FLY-IT-YOURSELF"

Aviation Service Planned for Plane-Less Flyers

IN SPITE of all the remarkable things that have been accomplished by American aviation, the opinion is justified that we are only on the threshold of the air age. Signs of such an age are not lacking. Thus from Boston comes the announcement that R S. Robie is planning a fly-it-yourself service for use by air-minded men and women. Mr. Robie expects that young men who have been engaged for two or three years in war-time flying will come back fully ready to patronize such a service. Here is his plan:

"The 'fly-it-yourself' plane will be rented on an hourly basis. You will pay only for the amount of hours you use in actual flight. The cost per hour for a small plane will be $3.50 to $5 00 The airplane will be equipped with a three-way radio (receiver, transmitter, and direction finder)."

All this sounds too good to be true, but Mr. Robie adduces some sound arguments. There are now scarcely any cities or towns of any size in which an airport or at least a landing field is not available. In addition, appropriations are forthcoming for "flight strips." These flight strips consist of concrete runways from 500 feet to a mile in length, running parallel and adjacent to large highways at points close to cities and towns. These will, in effect, be small airports which will multiply our facilities many times.

Detenderizing Glass

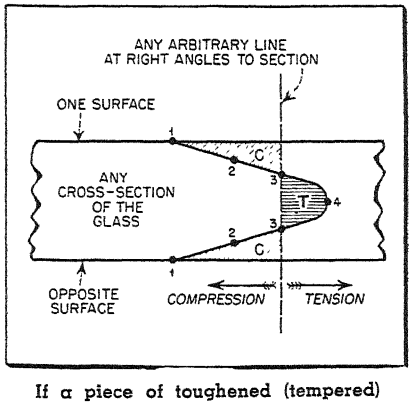
Not All Glass is Fragile. Glass Intended for Safety Lenses is Changed from Tender to Tough by the Comparatively Simple Application of a Trick That Reverses its Normal Stresses and Puts the Surface Under Compression Balanced by Internal Tension. Industrial Eye Injuries Can be Reduced

By T A. WALSH
Manager, Safety Engineering Service Bureau
American Optical Company

EACH year, thanks to optical science, thousands of eyes are saved by safety goggle lenses which are scientifically toughened to resist the impact of flying objects often encountered in certain types of industrial operations From an economic point of view, a safety goggle that saves an eye pays for itself about one thousand times over, and a goggle that prevents the most trifling eye injury pays for itself several times over.

Eyes are the most vulnerable and the most expensive targets which workers present to industrial hazards. The smallest chip, the smallest spatter of acid or molten metal, can score a bull's-eye, rob a worker of his sight, and cost his company $1800 or more in compensation alone, not including the indirect costs which invariably follow. Even a trifling injury, only serious enough to cause a single trip to the infirmary or first-aid station, may run up serious "hidden" costs in idle machine time, lost production, disrupted production schedules, and in lowered efficiency of the man involved and of neighboring workers.

To protect the eyes of war production workers, millions of toughened lenses have been turned out since Pearl Harbor The need for these lenses will increase as new manufacturing processes which create eye-injury exposures are expanded in plants now generally considered as having a low eye-injury hazard.



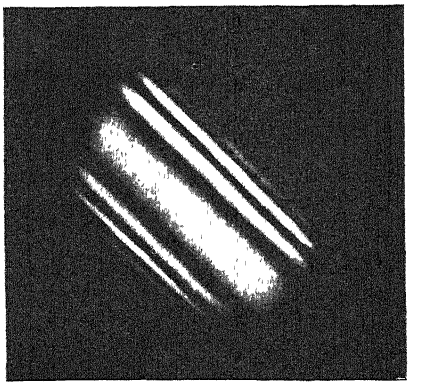
If a piece of toughened (tempered) glass is sectioned, the following condition will be found, according to C. J. Phillips, a Corning Glass Works physicist. At points 1, on the outside surfaces, there will be a maximum compression perhaps as high as 15,000 pounds per square inch or even more. At points 2, just inside each surface, there will be a smaller stress in compression, perhaps 7500 pounds per square inch. At points 3, there will be zero stress. But at point 4 there will be a tension which may be roughly 5000 pounds per square inch. Area *C* is in compression, area *T* is in tension

How is fragile glass made tough enough to ward off flying chips of metal and thus protect the eyes of industrial workers?

To explain and understand the art of toughening lenses it is first necessary to discuss glass annealing. Briefly, annealing is a scientifically controlled heat treatment to make glass optically homogeneous. The glass is brought to the top of a certain temperature range, kept within that range for a long period of time, and then allowed to cool. This procedure eliminates mechanical strain and stabilizes the internal structures of the glass.

Incorrect annealing may permit dangerous concentrations of internal stresses and strains to exist or to develop later after the annealed glass has reached room temperature. It is these uncontrolled stresses and strains, often developing in after years, which may cause glass to break, frequently for no apparent reason—as in the case, for illustration, of a cut-glass goblet that may suddenly crack while resting on a shelf.

HOW IT IS DONE—In toughening glass, as C. J Phillips points out in his book, "Glass: The Miracle Worker," it is deliberately disannealed, under controlled conditions, so that when the glass cools it contains desirable permanent compressive stresses in all its outer surfaces. Controlled strain is introduced by reheating the annealed glass, after it has been formed, to a temperature just below its softening point and then rapidly cooling the surfaces. This chilling process is accomplished by means of jets of compressed air, immersion in oil, or plunging in various molten salts. In practice, all three procedures are used in toughening lenses.



A section of toughened safety lens, taken under polarized light, which reveals the tension (inner band) and compression (outer bands) in it

Correctly done, this rapid chilling places the exposed surfaces in compression, balanced by tension inside, and this system of stresses is as permanent as the glass body itself. Actually, the outside of the glass—its weakest part—is strengthened by the process, as explained below

To understand what happens it is necessary to have a clear picture of compression and tension. Suppose we take a rubber band and stretch it. It is now in tension—that is, the atoms are being pulled down. Continue to stretch the same band and eventually there is so much tension that the atoms part company and the band breaks.

Compression is the exact reverse of tension. By pressing together a substance—a rubber eraser, for example—we move the atoms closer together despite repulsion forces existing between them. Continue to compress the eraser and it is found almost impossible to reach a pure compression force large enough to cause a rupture

In toughening glass, according to J. T. Littleton, of the Corning Glass Works, the simple principle is applied of creating a stronger body by generating an internal tension, in order to furnish a region under compression.

Delving deeper ınto the process, ıt found that, by controlling the rate f cooling of the glass from a temperaıre sufficiently high to render the glass ightly plastic, an internal tension reılts. This is because, during the coolıg process, the surface of the glass ɔols more rapıdly than the inside of ıe glass and therefore becomes rigid rst.

This would cause a differential con·action, except for the fact that the ıterior of the glass is still plastic and ields to the stresses set up in the coolıg However, as the glass continues to ɔol, its inner part becomes hard and ın no longer yield.

Finally, as the glass becomes cooled ɔ a temperature near that of the room, ıe temperature difference between the

One of the rotary-type heating and chilling units mentioned in the text. Note radial rotating arms below. Each arm carries three lenses through an electric furnace

ırface and the inside gradually disɔpears. At the moment when the cool ıtside surface of the glass becomes gid the hotter inside, because of its astic condition, will still be contractg as its temperature falls. The inside , therefore, put under tension. How·er, since the glass is a continuous ılid—and, according to Newton, to ·ery action there must be an equal ıd opposite reaction—the outside surce must from necessity resist and ılance the contracting pull or tension the inside, hence it is compressed ıd thus toughened.

NOTHER EXPLANATION—Here is anher way of explaining what happens. lass bodies ordinarily break only hen some point on their surfaces ·aches a tension exceeding a certain nount. If these surfaces are normally a state of compression before loading, is compression must be overcome ıd then tension built up, before breakːe occurs. The surfaces of toughened ass are therefore stronger by about e amount of the compression introıced by the cooling.

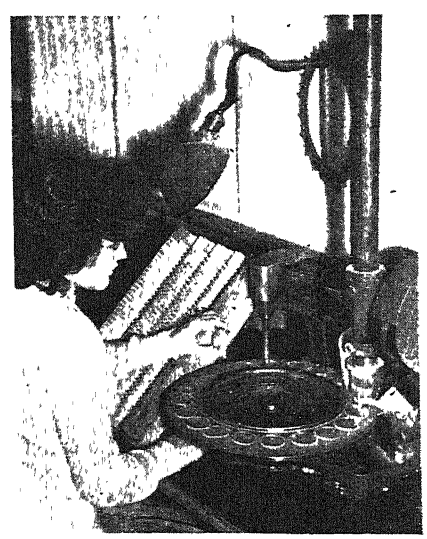
As the permanent compression can sily be 7000 pounds per square inch ıd may be as much as 20,000 pounds r square inch, thermally toughened ass may be several hundred percent ronger than annealed glass. For exaple, comparing the strength of annealed glass plates and thermally toughened plates of the same composition, the annealed glass gives strength values from 5000 to 7000 pounds per square inch and the thermally toughened glass 25,000 to 27,000 pounds per square inch.

Great mechanical strength, as the above figures show, is provided by the toughening process, which produces a glass having remarkable flexibility and resistance to impact and other mechanical shock. Furthermore, if the glass does break, it does not shatter into long sharp splinters but crumbles into small cubical pieces. This is because toughened glass takes on the characteristics of crystals which break along their planes.

To turn out toughened lenses in the quantities needed in the modern industrial world, American Optical Company engineers have designed rotary-type heating-chilling units, each of which, in the hands of an expert operator, can toughen thousands of lenses a day. The machine is composed essentially of an electric furnace, rotating arms which carry lenses through the furnace, and jets for compressed air used in the chilling operation. These jets are especially shaped to provide the desired distribution of air over the heated lenses, an exceptionally important part of the toughening operation

DONE IN FIVE MINUTES—In one revolution of the rotating arms, which takes approximately five minutes, 60 lenses are toughened. Heating temperatures range from 1200 to 1600 degrees, Fahrenheit, and different temperature cycles must be determined for various types of glass used in manufacturing toughened glass.

A brief description of a typical safety lens is as follows: Super Armorplate lenses, chosen as the example, are available in two forms—1.25 curve and 6.00 curve—optical designations which indicate the degree of curvature of the lens surfaces Both forms are made



Testing safety lenses for toughness. As each lens is positioned under the pipe column at the right, a 5/8-inch steel ball weighing over half an ounce is dropped from a height of six feet and strikes it

Safety goggle lenses ground to prescription to correct defective eyesight can also be toughened. In two minutes the above special heating-chilling machine tempers a prescription safety lens so that it resists breakage. The girl wears a pair of these corrective-protective lenses

from ophthalmic crown glass, optically ground and polished. Toughened by the above method, these lenses are fracture-resisting to the highest practicable limits obtainable by modern science They exceed the National Bureau of Standards requirements for a protection lens.

The 6.00 curve Super Armorplate lenses are deep curved for extra strength. They provide even more resistance against impact than 1 25 curve protection lenses, plus greater likelihood of deflecting flying particles. The deep curvature permits them to fit closer to the eye, yet give greater eyelash clearance. Reflection from the back of the lenses is reduced.

For workers exposed to both impact and glare hazards, there have been made available lenses combining the impact resistance of 1.25 curve or 6.00 curve Super Armorplate plus the glare-free qualities of colored absorptive glass. These lenses screen out ultraviolet and infra-red rays and reduce glare.

Safety goggle lenses are now ground, polished, and edged before they are toughened, a comparatively recent innovation and one that has improved the quality of the lenses and lessened their breakage during production. Previously, the finishing operations were performed after the lenses had been toughened, a method which thinned the compression band of the lenses and thus frequently caused breakage.

GROUND FOR EACH USER—Several years ago there was developed a method of toughening safety goggle lenses ground to prescription to correct defective eyesight. Small toughening units were designed for the purpose and after many months of research a comprehensive chart was worked out, providing heating-chilling data for toughening white and colored prescription safety lenses of different thicknesses and curves. Because each prescription lens is individual, prescribed

ror one person s eye, compilation of data for a chart covering all thicknesses of lenses represented a monumental research task.

The importance of this latter development lies in the fact that many of our industrial workers are now men of middle age or beyond who seek safety goggle lenses which protect their vision and correct it also. When elderly workers wear such eye-protective and eye-corrective goggles their production naturally increases, and they achieve greater eye comfort, efficiency, and safety.

A few figures reveal the importance of safety goggles in dollars and cents. In 1929, a company in the metal working industry employed 41,500 people, and its bill for eye accidents in that year alone was $51,000. An eye protection program was inaugurated. In 1936, the company employed 43,500 employees or 2000 more people than in 1929. The bill for eye injuries, however, dropped to $5800.

In another plant, the cost of eye injuries was reduced through the medium of an eye protection program from approximately $2.70 per employee to 7 cents per employee in the period of 1943 over 1942.

In the 1943 edition of "Accident Facts," published by the National Safety Council, it was shown that the total economic costs of 1942 occupational accidents are estimated at approximately $2,300,000,000. Industry's burden through these injuries is estimated at $1,900,000,000, of which $95,000,000 can be attributed to compensation paid for eye injuries.

This is an unnecessary economic loss.

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"ONE ESSENTIAL INGREDIENT"

Controls Size of Molecules

In Synthetic Rubber

No longer of value to the enemy, one of the prime secrets of the success of the entire Government synthetic rubber program can now be told. It rests with three little letters chemically termed OEI, and is called the "One Essential Ingredient."

This chemical, extracted from a natural oil, acts as a regulator to control the growth and structure of the giant molecules which, in turn, determine the properties of the finished synthetic rubber.

OEI, the chain modifier or regulator which governs the properties of the finished products, was experimented with and produced by United States Rubber Company long before Pearl Harbor.

This modifier, which has a base of natural oil, was the only chain modifier suitable for the rubber program. The supply of raw material was accessible and the methods by which the finished chemical was produced, while elaborate, were more efficient and time saving than any other known method of manufacture.

While other essentials in the manufacture of synthetic rubber, such as butadiene and styrene, are derived from coal, oil, alcohol, and gases, OEI is made from chemicals which are extracted from natural oil. Added to the mixture of butadiene and styrene, this chain modifier controls the lengths of the chains formed through the marriage of the butadine and the styrene. Too much of this chemical added to the mixture keeps the molecules too small, thereby producing a mixture which becomes soupy and of no practical use. Too little added to the mixture allows the molecules to become too large and to create cross linking of molecules instead of chains, thereby making the mixture too stiff.

Proper control of the modifier governs the mixture to a point where polymerization is accomplished with chains of molecules produced at desired lengths. This consistency of production assures a standardized mixture at all times and permits the manufacture of completed tires, tubes, and other finished articles of war to meet stringent usage tests.

Since this rubber program for GR-S has been initiated, other modifiers have been found but to date OEI is still being used in practically all manufacture of Buna S synthetics

POST-WAR EDUCATION

Needs Intelligent

Planning and Directing

Higher education after the war is likely to become more "vocationalized" than ever before and its products more narrow and technical, Dr. Walter M Kotschnig, professor of education and child study at Smith College, declares in a survey of "The Professions" reported to the American Chemical Society.

There is real danger that returning members of the armed services will crowd into all kinds of "practical" courses which would appear to lead almost at once to remunerative positions, Mr. Kotschnig warns.

"Those of college level are likely to storm the vocational and semi-professional courses in our undergraduate colleges," he says, "and they will flood our graduate schools, even though the war prevented them from acquiring the broad education offered in the past by the liberal arts colleges. The cussedness of the whole situation stands revealed when we realize that this very trend towards the vocational and narrowly technical will result in more rather than in less unemployment.

"There are definite limits set by the laws of demand and supply beyond which no profession can expand at a given time. The artificial wartime expansion of the various technical professions, including medicine, is bound to result in an overcrowding of these professions under peace-time conditions, even without counting those who will try to prepare for these professions during the first years after the war.

"Undoubtedly many will take a more optimistic view. They will point to the fact that America is starved for consumer's goods and services, and that American products will be in demand for reconstruction purposes throughout the world. However, it must not be forgotten that many of the discoveries of war-time research are easily applicable to a peacetime economy. Put differently, a backlog of discoveries and inventions has been piled up on which we shall be able to draw for some time to meet the fondest hopes of the American consumer."

Real foresight on the part of educational and professional leaders during the early post-war years will be required, Dr. Kotschnig believes. There is no quarrel, he says, with a program to enable ex-service men to complete their interrupted formal education, but there is a real danger, he insists, in ever more "vocationalizing."

"In order to avoid much individual misery and minimize any possible threats to professional standards and possibly even the stability of American society, long-range planning is necessary," he continues.

"The first great need is to avert a rush toward training for overcrowded vocations among returning ex-service men through organized action and guidance arising from within the professions themselves. By this I do not mean the day dreams of starry-eyed reformers or the abstractions of theoreticians. It is for those who are closest to the situation to size up the problems and to devise ways and means of meeting them. This means the leaders of the professions themselves and educational statesmen who determine the policies of our institutions of higher learning."

ENGINE INDICATOR

Measures and Photographs

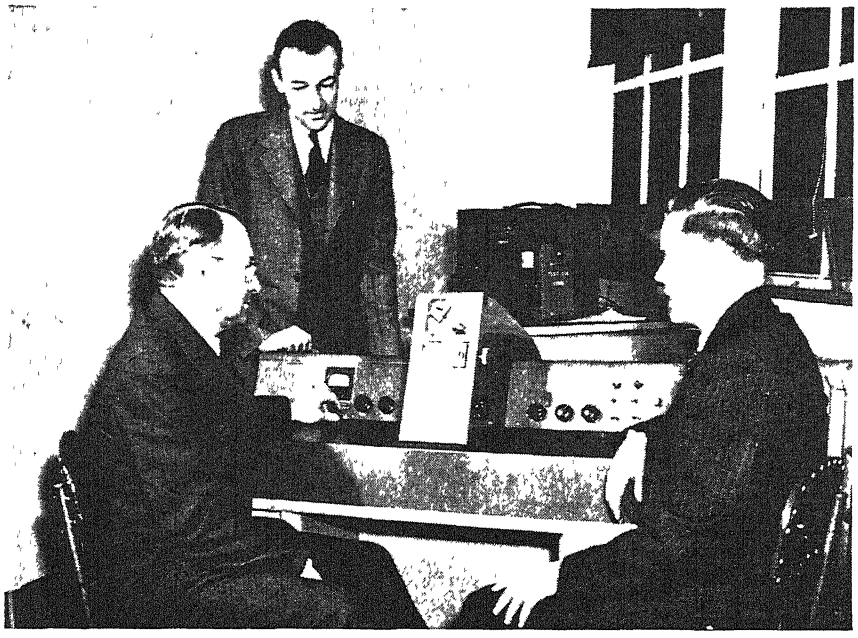
Interior Details

Another progressive step in the process of revealing to automotive engineers what really goes on during the operation of the engines they design and build was reported to the recent SAE National War Materiel Meeting. The meeting was told that an improved indicator for measuring both static and dynamic pressures can be applied to the various tasks of measuring vibration in engines; determining pressure surges in oil-circuit breakers; ascertaining deflection in engine flywheels, cylinder heads, and blocks; recording detonation; measuring pressures in guns; and even making jet-propulsion studies.

Not only does the indicator make measurements, it was explained, but, used in combination with a camera, it creates permanent visual records

Design, development, and operation of the indicator were described by C. E. Grinstead, R. N. Frawley, F. W. Chapman, and H. F. Schultz, all of Research Laboratories Division, General Motors Corporation

Presenting results of tests demonstrating the efficacy of the indicator in probing the secrets of engine operation, they showed a calibrated, high-pressure, combustion-chamber record of an aircraft engine running at 2600 revolutions a minute. Other records



showed pressure changes within an engine manifold.

The electrical condenser-type indicator was described as sufficiently small to permit installation on modern engines, so rigid as to minimize the effects of vibration, and so critical as to register manifold pressure changes of as high as 6000 cycles per second

NEW ELECTRON MICROSCOPES

Extend Field of Usefulness of This Important Scientific Tool

TWO NEW RCA electron microscopes —one a universal model which incorporates an electron diffraction camera and the other a smaller console model of an entirely new type—were announced recently in a paper presented jointly by V. K Zworykin, James Hillier, and Perry C. Smith of the Radio Corporation of America before the National Wartime Conference of the Society of American Bacteriologists.

In the first part of the paper, comprising a review of recent developments in electron microscopy pertaining to the field of bacteriology, Dr. V. K. Zworykin, Associate Director of RCA Laboratories, and Dr. James Hillier, pioneer in the development of electron microscopes, disclosed important new applications of the electron microscope in this field, among them the use of this powerful electronic magnifying device in a study of the effects of disease-inhibiting drugs such as penicillin and sulfanilamide. Also exhibited for the first time were electron micrographs of high magnification which showed minute anatomical details of *Anopheles quadrimaculatus,* the malaria-carrying mosquito.

Speaking to a large audience of the country's most eminent bacteriologists, Dr. Zworykin and Dr. Hillier pointed out that since its introduction in 1940, the RCA electron microscope has grown steadily in prestige and usefulness until today there are more than 60 in use, with many more on order. The experience gained with this group of in-

Above: Drs. Zworykin (seated, left) and Hillier (right), and Mr. Smith, with the new small sized electron microscope. Right: The new universal electron microscope incorporating many recent improvements

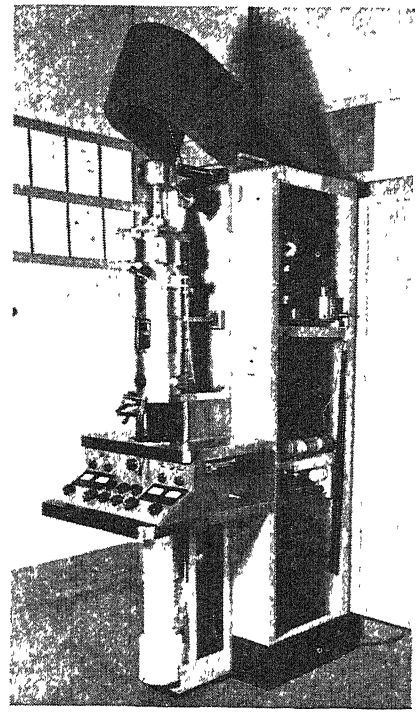
struments, practically all of which are located in leading research laboratories, has made it possible to define more accurately the advantages of the electron microscope, the results which may be expected, and the fields in which it will find greatest application.

The new universal model of the RCA electron microscope represents a complete redesign of the laboratory type instrument which has been in production for the past four years. It incorporates many improvements and simplifications in mechanical and electrical design which make for more convenient operation, more consistent results, and greater ease in servicing. The field of application has been broadened and the usefulness increased by including an electron diffraction camera as a built-in unit. Thus, it is now possible to make electron micrographs and electron diffraction patterns of the same specimen in a matter of minutes. The extra information gained is often of great value in determining the molecular structure of a substance. The electron diffraction unit alone may sometimes be used in identifying unknown substances and in detecting impurities in known materials.

In the universal model the electron optical system is contained in the vertical column at the front of the instrument. The airlocks formerly used for inserting specimens and film plates have been eliminated, this being made possible by the fact that the whole column can now be pumped down in a minute and a half. The pumping system consists of an oil diffusion pump located in the lower part of the column, and a mechanical fore-pump mounted externally.

The console model of the electron microscope is an entirely new type of instrument designed to meet the need for a smaller, less expensive unit. It employs the same type of circuit as the larger microscope (including the highly desirable feature of magnetic lenses), is built to the same quality standards, and provides performance of the same order as its bigger brother. It does not, however, have a diffraction unit, has only two magnification steps (500 X and 5000 X) and lacks some of the convenience features of the big model

In the console model the electron optical system is mounted horizontally and the image appears directly on the screen at eye level. The whole equip-



ment, including oil and mechanical pumps and power supply, is mounted in a desk-type console

The console model is especially suitable for use in small laboratories, schools, and hospitals, and for process and material control in factories Because of its simplicity, it can be operated with a minimum of training It is particularly well suited for control and analysis operations which have been more or less standardized It is expected to find widespread use for this purpose in the chemical, metallurgical, textile, food, and petroleum industries as well as in the bacteriological field

PLANT SAFETY

Maintained by Direct Contact With Workers

THE experience of the Ford Motor Company in 30 years of safety work has shown that best results are achieved by direct contact between trained safety inspectors and employes. These safety inspectors are carefully selected. Many are designers or engineers, others are former tool and die makers, maintenance men and chemists. All have had a rich background of practical experience.

Maintaining personal contact between safety engineers and employes is no-

simple task, but it has paid dividends, not only in property, but in lives and limbs Difficulties have multiplied as a result of the rapid labor turnover caused by war conditions. The influx of women and former white-collar workers has intensified the problem of educating employes and keeping them safety-minded, but the company's high safety record has been preserved

Safety department inspectors keep constantly on the move. They talk to foremen and employes, study machines and operators' habits, and make suggestions.

Safety devices installed in the Rouge soybean plant are illustrative of the safety department's ingenuity The problem was to detect the possible escape of hexane, a highly explosive liquid used in soybean processing After checking the equipment and noting the points of potential danger, safety engineers placed suction pipes at each point Through these a sample of air is drawn once every three minutes, and if hexane is present the machine sets off an automatic siren At the same time a light flashes on an instrument panel showing the location of the leak

Ford safety engineers must approve all new equipment before it can be purchased. If specifications are approved, the buyer places his order. Upon arrival of the shipment the safety inspector again checks the machine to make certain it meets specifications. Alterations are frequently needed But in no case is any machine installed until it is approved by the safety department, even though a major change in design is necessary

CAR VS PLANE

Two Experts Discuss Possible Post-War Features

THE DEVELOPMENT of radical automobiles has quite definitely been assigned to the post-post-war period. The reasons Automotive engineers now are too busy with the production of war materiel to bother with advanced designs Immediate post-war demand will be for modified 1942 models—in a hurry The public accepts revolutionary automotive engineering and design slowly and in mild doses.

Any automobile even bordering upon the revolutionary must be a post-post-war model, says Brooks Stevens, industrial designer, adding

"It is unfair and unwise to lead the public to believe that the day after our final victory it can be assured of plastic automobiles for $400 each, privately-owned helicopters within the automotive price range, and household appliances that will almost eliminate the necessity for domestic help."

Future automobile design rests entirely with the consumers' ideas, says W. B. Stout, of Stout Research Division, Consolidated-Vultee Aircraft Corporation. He expresses the opinion that the future car must serve the public's urge to travel, declaring. "The most startling post-war car will have wings."

Insisting that production practicalities largely will discount the unrealities of post-war dream products, Mr. Stevens deflates proposals for radically-styled, all plastic, rear-engine, post-war cars He says that the public likes to look at such vehicles, but won't buy them, and predicts that the first post-war cars will be revised 1942 models, available possibly six months after peace begins.

In the subsequent period of transition, suggests Mr. Stevens, designs may change. Fenders may disappear into smooth, simple, steel bodies devoid of chromium ornamentation, but transparent "goldfish bowl" bodies are out They're too revealing, too hot. and so difficult to repair that the wife who is prone to dent fenders would be unable to get the marks erased before her husband discovers the damage.

Mr. Stevens looks for smaller, lighter cars to meet rising costs and taxes, but with increased passenger space and riding comfort Adequate reasons for rear-mounting of engines may be found; otherwise design details probably will follow the sound 1930-1940 engineering trend

The modern automobile, while satisfactory for city driving, is too slow for the open road, asserts Mr Stout, who sees the needs of the post-war American for either a "roadable airplane" or a "flyable automobile."

"It is my belief," he says "that the first step will not be so much a roadable airplane as a flyable automobile. First, it must be a good city automobile that the purchaser can buy and use four or five days a week driving back and

The Microscope That Changed the Course of Science

Here you see one of the earliest Bausch & Lomb microscopes.

This was the first microscope produced by quantity production methods . . . the first precision compound microscope to be made at a price which the average research worker, educator or medical man could afford. These microscopes made research and study possible in America on an unprecedented scale.

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forth to work, but on the week-ends, or vacation, one which he can drive to the airport, put on his wings, and go 1000 miles Once on the ground again, he must have a good automobile with regulation motor-car transmission, brakes, tires, and so on, such as fit road problems."

Wartime manufacturing developments are said by Mr. Stout to make it possible for many firms, contemplating diversified post-war products, to enter the automobile field. He declares that the flexible operations of the aircraft industry are particularly adapted to this purpose, and they can produce new models every few weeks until the public is satisfied.

SYNTHETIC PACKING

Resists Strong Acids and Alkalies

Now being used as packing material in pipe lines carrying the hydrofluoric acid used in the manufacture of high-octane gasoline, "Vinyon" is ideally suited for the purpose, according to the American Viscose Corporation. It has the ability to resist strong acids and alkalies, such as sulfuric, nitric, and hydrofluoric acids, aqua regia, caustic soda, and potash.

YARN TWIST

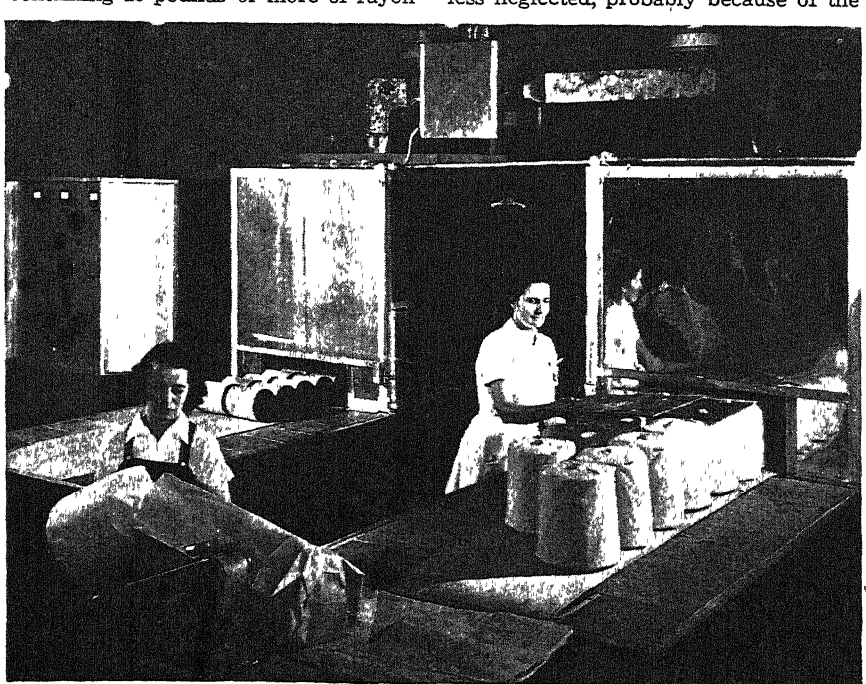
Setting Expedited by Electronic Heating

All rayon tire cord manufactured by Industrial Rayon Corporation is subjected to electronic heating in a new process invented by the company's technical staff to solve problems in the twist-setting of textile yarns.

The twist of the rayon tire cord is set by placing packages of the cord in a high frequency electrical field. Heat generated in the cord by this operation is distributed so uniformly that cones containing 18 pounds or more of rayon tire cord may be effectively treated. Such giant cones are used in the weftless method of tire construction.

The process is completed in a matter of minutes and results in the production of a cord in which the twist is uniformly set. Control of the moisture content of the cord may be facilitated by wrapping the cones of cord in moistureproof paper and processing them in this form.

The equipment originally installed for this process has been in operation at one plant for more than eight months and includes high frequency power generating units having outputs of approximately 22,500 Btu per hour each. They were furnished by the Girdler Corporation, through its Thermex Division, and each unit is capable of handling several thousand pounds of packaged tire cord in a 24-hour period.



Twist of rayon tire cord, in 18 pound cones, is set in electronic heater at right

THERMAL SHORT CIRCUITS

Are Important to Industrial Designers

When you "blow a fuse," the lights go out. When you break the handle of your coffee pot and try using it without adequate thermal insulation, you burn your fingers. There is an important analogy between these two phenomena, according to a paper entitled "The Influence of Through Metal on the Heat Loss from Insulated Walls," by Victor Paschkis and M. P. Heisler, delivered at a session of the American Society of Mechanical Engineers.

"Everybody knows, by experience, 'short circuits' in electric systems," the authors declared. "They occur when the 'hot wire' part of a circuit is connected, through a low resistance, to some metallic body like a house plumbing fixture. In the realm of heat flow quite similar phenomena occur.

"While electric 'short circuits' have been studied extensively, 'thermal, or heat, short circuits' have been more or less neglected, probably because of the difficulties of an exact analysis. These difficulties have been largely overcome by the recently developed 'Electric Analogy Method.'

"This method," the authors continued, "underlies the work of the heat and mass flow analyzer laboratory in the Mechanical Engineering Department at Columbia. Extensive experiments have been carried out on the heat and mass flow analyzer which have resulted in better knowledge of 'thermal short circuits.' This analyzer, along with so many other devices, has been named an 'electrical brain.'

"There are innumerable cases in industry where 'thermal short circuits' occur—ships hulls, metal encased refrigerators, domestic and industrial furnaces and ovens, both electric and fuel-fired, strato chambers, and brick-mortar structures. Nearly all insulated structures involving the use of materials of widely different thermal conductivities suffer from it."

The authors explained the application of their research to one industrially important "thermal short circuit." While the research is incomplete, the paper said, the work already carried on has been of value to the individual industrial concern, in that it gives the designer the possibility of calculating the effects of heat loss. Further experiments are planned, extending to other design patterns.

GASOLINE INJECTION

Reported to be Perfected

Engineers for years have sought for a practical method of gasoline injection for supplying fuel to the cylinders of gasoline engines. Such a method has now been perfected and is in production, according to Donald P. Hess, President of American Bosch Corporation.

Higher efficiency, even with lower-grade gasoline, greater responsiveness, smoother power delivery, and elimination of the fire hazard of an explosive mixture of gasoline and air in the induction system, are some of the advantages for the new fuel distribution system, which replaces the conventional carburetor.

"The gasoline, by this system, is delivered uniformly to every cylinder of the engine. The result is that all cylinders pull together in harmony, producing a smoother flow of power and quieter engine operation than has ever been possible with any other method," Mr. Hess states.

"The engine equipped with gasoline injection responds instantly to the touch of the throttle. Time lag is eliminated, acceleration is smoother, and the engine performs more surely under all conditions. The safety factor is important in wartime, and will be equally so when applied to busses, trucks, and other types of public carriers in the post-war world," Mr. Hess adds. "Backfires are eliminated by this method, because the fuel, either in fuel or vaporized form, is confined within the engine cylinders. The air induction

system carries air only, which is not mixed with the fuel until it reaches the cylinders By the use of this system, all fuels, even lower grades, burn more completely and efficiently. Thus, a greater proportion of their potential power is delivered in the form of useful energy. Mileage per gallon increases, cost per mile decreases"

Gasoline injection is a method of fuel delivery adapted from the Diesel engine, in which fuel is delivered to the cylinders in much the same way. Military uses of gasoline injection are shrouded in secrecy, but they are said to be many and varied.

WATER PIPE

Gives Long Service

When Rubber Lined

RUBBER lined pipe has shown its value in coal-mining operations in certain territories, according to a report just received by The B F Goodrich Company.

In one of the West Virginia mines, a pipe line which carried water out of the mine had to be repaired or replaced every five or six months because the water picked up sulfur and this created an acid which corroded and ruined the pipe

Several sections of this pipe line were replaced by rubber lined pipe; this has now been in service five years and is still in excellent condition, the report says

PEACE THROUGH SCIENCE

Possible Only if Technologists

Assume Responsibility

LASTING peace through science was envisioned by Walter J Murphy, editor of *Industrial and Engineering Chemistry,* in an address recently delivered before the University of Michigan Section of the American Chemical Society.

Scientists and technologists, by bringing abundance to all peoples, can overcome the predatory forces which, exploiting economic unrest, foment wars. They must participate in the making of a peace to end "the unholy wedlock of science and the base instincts of man, a tragic and unhappy union from which has stemmed most of the misery of mankind," Mr. Murphy declared.

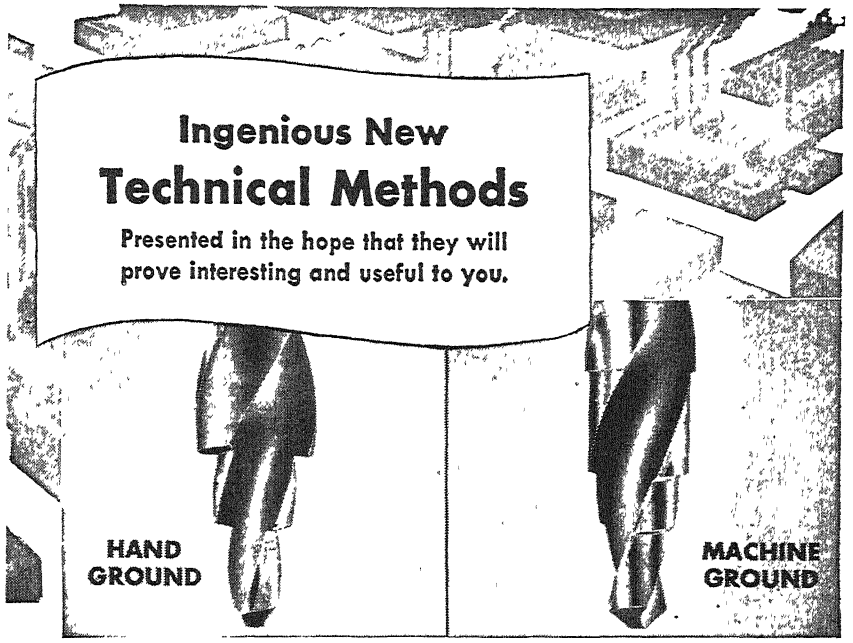
Science and technology alone can bridge the gap between the "have" and "have-not" nations, said Mr. Murphy. Failure to employ a scientific approach in writing the peace which followed World War I made inevitable the global conflict now in progress, according to Mr. Murphy, who asserted that war can be prevented only by the technologists of the world working in unison.

"For centuries discoveries of scientists have been basely prostituted by politicians and dictators bent on personal glory and national aggrandizement," continued Mr. Murphy, whose subject was "The Chemist's Responsibility in War and Peace." "For hundreds of years Napoleons and Hitlers have seized upon the work of the technologists in the hope of conquering their fellowman and subjecting him to abject slavery. Scientists have failed to control the fruits of their discoveries for the betterment of mankind through failure actively to assert their proper rights.

"To obtain the opportunity, however, of applying the scientific approach to writing the kind of peace that should follow World War II we must first destroy the evil forces now loosed upon the world. Without the American chemical industry as we know it today the task would be hopeless. The contributions of the chemist, the chemical engineer, and the chemical industry to the winning of World War II constitute one of the most dramatic stories of all time.

"When details can be told of the programs for synthetic rubber, 100-octane gasoline, toluene, alcohol, light metals and alloys, plastics, and a thousand and one other essentials of modern all-out-war, the American populace will appreciate that the men of science, quietly working in their laboratories without spectacular fanfare, have contributed tremendously to the saving of mankind and to the prevention of a return to the Dark Ages.

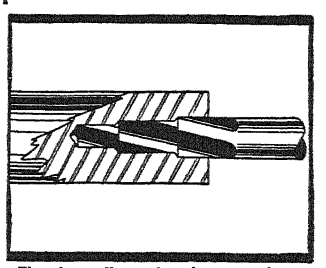
"In attempting to take practical steps toward refuting the impression that technologists are all 'shrinking violets' and that scientists cannot take a more active role in controlling the uses of technological advances, reserving them for the betterment rather than the destruction of mankind, we must make a determined effort to refute the generally-held belief that to



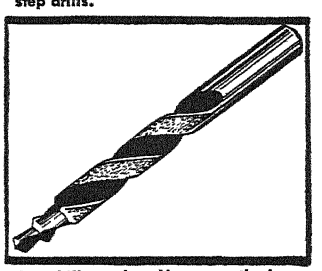
New Precision Step Drill Grinder Simplifies Production and Maintenance of Step Drills

The quality of a step drill produced by common methods depends almost entirely on the skill and attention of the individual tool maker. However, with the development of the precision step drill grinder, the human element has been entirely eliminated, the characteristics of the step being completely controlled by the grinding machine without adjustments during the course of grinding. This automatic feature insures absolute uniformity, regardless of quantity, and permits large-volume production of step drills.

The apparent advantages gained through the use of the step drill grinder are: Permits mass production of drills ground to exact specifications, entirely independent of the human element. Maintenance, too, is no longer an obstacle as step drills produced by this method are quickly sharpened by the same uniform machine-controlled operation. With the step drill grinder step drills can now be made from standard drills. These advantages result in a wider application of step drills which provide a definite saving of machine tools, man-hours and cost; this in turn results in greater production.



The above illustration shows mechanical design which requires a hole having diameters diminishing in steps. This is an operation for step drills which has often been neglected due to difficulty in obtaining and maintaining step drills.



Step drills produced by our method are quickly sharpened by the same uniform, machine-controlled method.

You know there are plenty of benefits in chewing gum, too. That's why all of the Wrigley's Spearmint we're able to make from our available stocks is going overseas to our fighting men and women. You know what a lift it's been on the job and we wish we could supply everybody, because we have pride, too, in our workmanship and productivity. But there just aren't enough available tóp quality raw materials right now to do it. When we can produce it in sufficient quantity, it will be back to you with the same fine flavor and chewing satisfaction ...Wrigley's Spearmint has never been changed!

You can get complete information from Spiral Mfg. Corp., 5022 North Kedzie Avenue, Chicago 25, Ill.

Y-125

be a highly successful scientist an individual must be an extreme introvert.

"The technologist must and will assume a much more important place than he has heretofore asked for or enjoyed, and when he has the courage to assume these greater responsibilities he will make it possible for the people of the earth to live constructively, sharing the abundance which science and engineering skill have developed. To do otherwise means physical, social, cultural, and moral bankruptcy for millions of human beings now alive and countless generations yet to come."

POWER BRUSHING

Reclaims Auto Parts Quickly and Efficiently

THE APPLICATION of power brushing to the salvage of parts from wrecked or otherwise junked automotive vehicles for re-use in service for which new parts are unavailable due to lack of production during war time has been largely responsible for keeping many

A wire brush reclaims auto parts

passenger cars, trucks, and busses in operation which, otherwise, would have been out of service. It is reported that this parts salvage activity is carried on by leading garages throughout the country in order to maintain some semblance of replacement parts inventory.

As used in automotive parts reclamation, power brushing does in two or three minutes the work of removing rust, grease, scale, and dirt that would take 15 to 20 minutes by the former hand method.

The parts to be cleaned are simply gone over with a power-driven brush, spinning at 3600 revolutions a minute In addition to doing the job eight to ten times faster than other methods, power brushing provides the further benefit of removing burrs, nicks, and so on. In this respect it can be said that certain parts are even better after power brushing than when new.

The equipment used for the work consists of either a portable hand tool, electric or compressed air operated, or standard polishing jack in which is mounted a wire brushing wheel. Held so that the wire ends contact the surface to be cleaned, the spinning wheel makes short work of grease, scale, and rust removal, according to The Osborn Manufacturing Company, producers of power brushes

ALCOHOL FROM WOOD

Is Good Insurance Against Grain Crop Shortage

A POSSIBLE non-grain source of alcohol to the extent of one hundred to one hundred fifty million gallons per year for essential uses such as synthetic rubber production is predicted by Professor Donald B. Keyes, University of Illinois chemical engineer on war-time leave as Chief of the Chemical Industries Branch of the Office of Production Research and Development

This additional amount of alcohol, obtainable as a direct product of wood, might be needed in case of a severe drought and a grain shortage this summer, since the principal source of alcohol today is grain. To acquire the necessary "know how," Dr. Keyes points out that the War Production Board has approved the construction of a full scale commercial plant based on processes already developed by his organization and the Department of Agriculture's Forest Products Laboratory. It will serve as an "insurance plant"

"It is recognized that this particular plant will not be a peace-time success until the lignin by-product can be sold at a profit," Dr Keyes says "Once the plant has been built and operated, lignin will be available in quantities for further experimentation and the results of study and development may make the whole process profitable in peacetime.

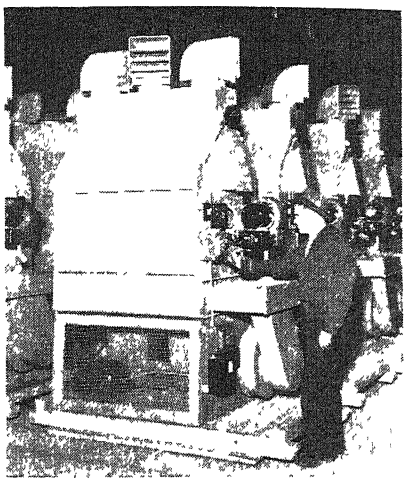
"Even if further development of plants is not justified, this one plant will be worth while by giving us the necessary know-how to build duplicate commercial plants without delay," he states. "This will mean that from an insurance standpoint we shall be well protected in any future emergency so far as alcohol from non-grain sources is concerned."

UNIT HEATERS

Designed to Burn Either Gas or Oil

TO MEET the problem of heating small structures and providing additional heat for limited areas, a direct fired heater with capacities ranging from 300,000 to 850,000 Btu output per hour has been developed.

This new model is one which the Dravo Corporation is supplying to the armed forces to heat steel service igloos at advanced bases. It retains the principal characteristics of the regular line of Dravo Direct Fired Heaters but on a scale in keeping with the smaller Btu output. Over-all size has been reduced in proportion, so that floor space requirements are now just 5¼ by 3 feet. It can also be suspended from the wall where floor space is not available. This model can be equipped to burn



Unit heaters ready for delivery

either gas or oil Oil burners may be quickly removed and gas burners and controls substituted as conditions direct The heater is thermostatically controlled and requires a minimum of manual attention. A small unit of this size can be used to complement present heating systems to provide additional warm air in remote parts of factories and other buildings.

COPPER ACCELERATORS

Speed Vulcanization of Synthetic Rubber

COPPER, long avoided by the natural rubber industry, was disclosed as a new and powerful agent in the production of synthetic rubber, at a recent meeting of the Division of Rubber Chemistry of the American Chemical Society.

This discovery, reported by Dr. A A Somerville, vice president of the R T Vanderbilt Company, will, it is believed, increase the output and improve the quality of synthetic rubber. Two new vulcanization accelerators for synthetic rubber, both chemical compounds of copper, were announced in a paper on "A GR-S Vulcanization Catalyst," by Dr. Somerville.

"These two accelerators, known as 'Cumate' and 'Cuprax,' are several times as powerful as the conventional type now in use in the rubber industry; and we believe that this greater activity is due to the fact that they are compounds of copper," Dr. Somerville declared.

"We hope that our discovery of the use of certain copper compounds will help the rubber goods manufacturers to increase output by increasing mold turnover, and possibly also to improve the quality of synthetic rubber products We have some reason to believe that the quality of products may be improved because one of the effects of adding copper is that less heat is built up in a Buna S compound under dynamic testing conditions."

"Why copper speeds vulcanization is still a mystery," Dr. Somerville said, in explaining the new development. "If you add a very small proportion of ordinary 300 mesh copper powder to properly compounded Buna S, the big tonnage synthetic rubber, and vul-

canize the mix in a mold in a laboratory press under standard conditions, you will find that this addition of copper has shortened the time of vulcanization to less than one half the normal time," Dr. Somerville said.

"The word 'copper' has been a 'hush-hush' word in the rubber industry until now because this metal and certain of its compounds act as catalysts of the oxidation of natural rubber, thereby greatly accelerating the rate of deterioration or perishing of natural rubber due to aging The use of copper in any form in natural rubber has therefore been carefully avoided, or if the presence of copper in natural rubber compounds was suspected copper antidotes have been deliberately added.

"In Buna S, however, all this is apparently quite different In Buna S, copper acts as a catalyst of vulcanization, not as a catalyst of oxidation. Buna S does not oxidize nearly so readily as natural rubber, and the presence of copper does not spoil the aging properties of Buna S. On the contrary, the aging properties of Buna S compounds, accelerated with the new chemical compounds of copper 'Cumate' and 'Cuprax,' are actually better than when conventional accelerators are used exclusively

CORROSION RESISTANCE

Said Due to Vacant Electron Spaces in Atoms

VACANT spaces in the atoms of nickel are responsible for its resistance to corrosion or "rusting," according to Dr. Herbert H Uhlig, Metallurgist of the General Electric Research Laboratory. In earlier researches, Dr Uhlig found that the stainlessness of stainless steel is not due primarily to the formation on the surface of a film of oxide, as formerly supposed. Instead, it results from the electronic arrangement in the atoms of the alloy. Now he finds that the same thing is true for two other widely used corrosion-resistant alloys. One is copper and nickel (Monel) and the other molybdenum, nickel, and iron (Hastelloy).

An atom may be thought of as a nucleus around which revolve, somewhat in the manner of planets around the sun, from one to 92 electrons. These move in from one to seven different orbits or shells. Ordinarily one shell is filled with electrons before the next one begins, though in the case of certain "transition" elements there are vacancies in the shell next to the outer one. In nickel, for example, there are only eight electrons in the third shell, instead of the 10 it could hold, despite the fact that there are two electrons in the fourth and outermost shell. With inner shells completely filled, a metal is more subject to corrosion.

Because of the vacancies nickel is very resistant to corrosion, but it is too expensive for many applications, and so it is alloyed with copper which is lower in cost. The atom of copper has one more electron than that of nickel. In the alloy these extra electrons go to fill the vacancies in the nickel atom. However, as long as any vacancies remain in the nickel the alloy still resists corrosion as well as pure nickel.

Finally, when the proportion of 60 percent copper and 40 percent nickel is reached, all the nickel vacancies have been filled. Further increasing the proportion of copper makes the alloy less resistant until pure copper is reached, which corrodes much more readily than pure nickel In the alloy of nickel with molybdenum and iron a similar effect occurs, says Dr. Uhlig

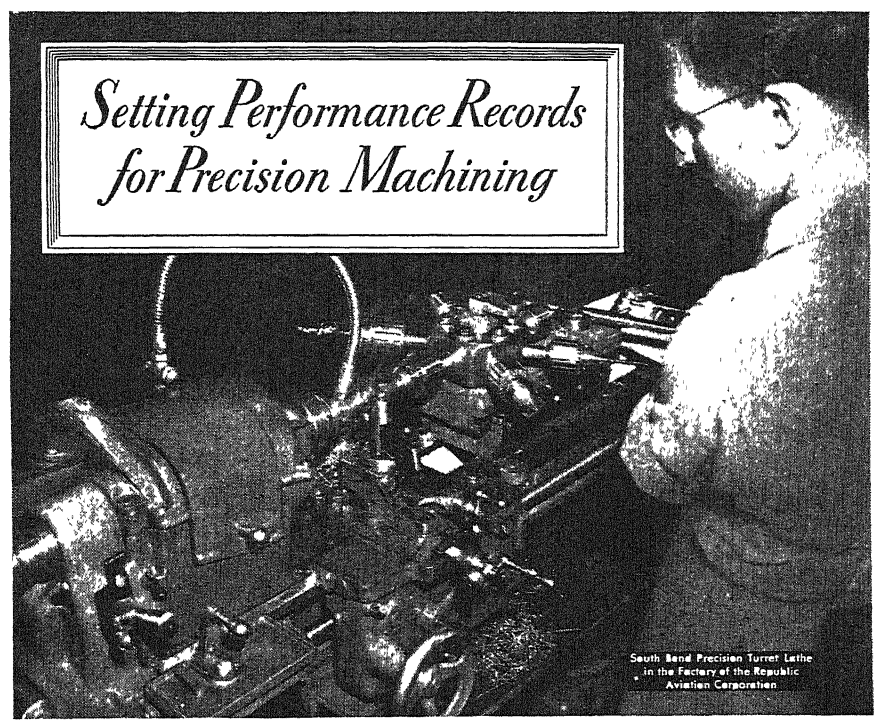
FERRETS AT WORK

Hold Down Sabotage By Rats and Mice

SABOTAGE is an all-inclusive term which runs the entire gamut of willful acts to destroy property or slow up production in war time Successful defense against sabotage requires the co-operation of the general public as well as the law-enforcement agencies, and it even drafts into service many furred and feathered creatures. Animals in particular have had quite a part in safeguarding various phases of war production.

An unusual application of animals in war plants may be cited in the use of ferrets to kill off vast hordes of destructive rats and mice. The bill against such vermin each year is a big one. Rodents eat through wood, paper, textiles, and similar materials to ruin valuable products, not to mention the diseases they may carry to working crews, necessitating the loss of many man-hours a year In the war against these unhealthy saboteurs, the rabbit hunter's bosom companion of bygone days—the ferret—is the number one police officer and detective. Sherlock the ferret tracks 'em down in their own lair.

An example of the importance of ferrets in industry today is found at one of The White Motor Company plants, where a posse of five ferrets has taken up the rat trail nightly for several months. The score against the rodents has amounted to some 40 to 50 dead rats a week. This is an average.



High precision and close tolerances have always been the watchwords of the aviation industry. But with the war came demands for higher speeds and better performance. This meant that even closer tolerances had to be established and maintained. We are proud that providing lathes to meet the exacting needs of warplane production is one of our important assignments. Throughout the aviation industry South Bend Lathes are setting enviable performance records for precision machining.

In all metal working industries, South Bend Lathes are giving the same dependable service that they are giving in the aviation industry. Versatile and efficient, they are also used for emergency service work in the Armed Services.

Now, as before Pearl Harbor, our entire factory is devoted only to the production of South Bend Lathes. There has been no lowering of standards because of wartime restrictions and shortages. The use of substitute materials is negligible, limited to non-essential parts. Improvements have been accelerated. Today, South Bend Lathes are better in every way.

South Bend Engine Lathes and Toolroom Lathes are made in five sizes: 9", 10", 13", 14½", and 16" swing. Precision Turret Lathes are available in two sizes. Write for Catalog 100-C.

POST-WAR PRIORITY PLAN

To those who cannot qualify for a wartime priority, South Bend Lathe Works offers a practical Post-War Priority Plan. You can place your order now for any South Bend Lathe. No deposit or down payment is required We ask only that the order be placed in good faith. When civilian production is resumed, orders will be filled in the sequence established by the numbers of the Post-War Priority Certificates. Should conditions necessitate, the order may be cancelled at any time Write for details of this plan

BUY WAR BONDS NOW...SAVE FOR LATHES

SOUTH BEND LATHE WORKS

LATHE BUILDERS FOR 37 YEARS • SOUTH BEND 22, INDIANA

Bathing an industrial ferret. Inset: Susie, one of White's rat catchers

Naturally the toll showed a favorable decrease as the ferrets secured their beachhead and gained control of the situation. But the job goes on because outside rodents can move in with crated shipments which arrive daily.

The ferrets are kept in special cages during the day, and at night they are released to go their way in quest of rats which they follow through partitions, under floors, and into shipping crates. Always they return to their cages in the morning When they were first released, signs were put up informing workmen that the furry creatures were on special rat mission.

The animals are fed a diet of bread and milk and given a bath twice a week with a mercury solution and castor oil Flea and louse powder are also applied.

GAS TURBINE FUTURE

Holds Possibilities in Ships, Locomotives, and Planes

THE GAS turbine, old in principle but not deemed practical as a prime mover until recently, now offers attractive post-war possibilities for hauling of railroad trains, propelling ships, and driving airplanes, according to J. Kenneth Salisbury, General Electric turbine engineer. However, he points out that it is improbable the gas turbine will replace large steam turbines in central stations.

"The large volume of air required by the gas turbine tends to limit its size at present," Mr. Salisbury says. "The gas turbine is not considered to be a competitor of the large, efficient steam plant, but rather as a reliable simple prime mover of intermediate capacity."

In discussing possible applications of the gas turbine, Salisbury states that General Electric has recognized its particular adaptability for use in locomotives and has made rather extensive studies of a 4500-horsepower locomotive powered by a single gas-turbine unit, with a regenerator and waste heat boiler.

"The thermal efficiency of this locomotive, its ease of assembly, accessibility, lightness of weight, and smooth flow of power, all indicate that it is an attractive application," he says.

Discussing aircraft application, Salisbury says that the experience of the present war has indicated that the future range of size required for aircraft engines may be from 2000 to 8000 horsepower.

"The light weight internal-combustion engine seems to be approaching a rather definite limit in rating," he states "The gas turbine, on the other hand, just comes into its own in the sizes at which the gasoline engine seems to be approaching a limit. Furthermore, it does not require expensive high-octane fuel for its operation. It is quite apparent that one potential gas turbine application is in the post-war cargo and transport plane field.

"What new uses will develop as time goes on depends only on the ingenuity of application engineers, together with the zeal and courage employed by the developmental engineers in perfecting this attractive prime mover," he concludes.

SYNTHETIC TIRES

Now Giving Satisfactory Wear on Passenger Cars

OF INTEREST to civilian passenger car drivers, concerned over the possibility that they might not be able to obtain new tires when their present tires wear out, is the announcement that Goodyear has already produced its 1,500,000th 6 00 by 16 GR-S synthetic rubber passenger tire—the popular size used on Fords, Chevrolets, Plymouths, and Dodges.

Satisfactory performance of these tires is shown, Goodyear officials say, in the result of a recent survey among users of more than 8000 of the tires. These users reported them to be 96 percent as satisfactory as natural rubber passenger tires.

While the milling of synthetic rubber takes longer and presents more problems than does natural rubber, other tire production operations take no more time. Dealers report a lower percentage of adjustments on GR-S passenger tires than on natural rubber tires, with many dealers asserting that the synthetic rubber passenger tires are of better quality than second and third line pre-war tires made of natural rubber.

Good news for passenger car drivers

Operators of a large fleet of taxicabs in a midwestern city, who use more than 3000 GR-S tires on their cabs, reported that the tires averaged 30,000 miles before recapping was necessary This approximate mileage figure has also been reported in other parts of the country.

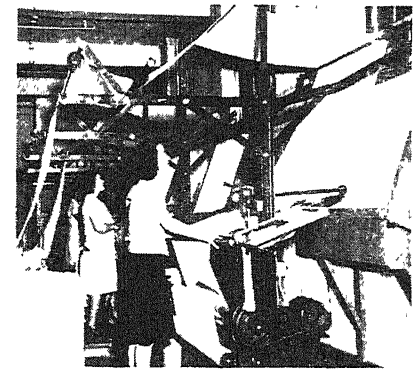
FLUORESCENT INSPECTION

Speeds Textile Output, Can Be Used Elsewhere

DEVELOPED for inspecting fabrics in textile mills but potentially useful in similar inspection of other translucent materials, a new fluorescent lighting device has been originated by Sylvania Electric Products Inc.

Catalogued as the "T-1 Sylvania Inspection Fixture," the device replaces former inspection methods which were unsatisfactory. The initial user, the Verney Mills, reported greatly improved quality control. It was also reported that each operator's daily output was increased by 1000 yards, or from 20 to 25 percent.

The unit consists of a box four feet long, three feet wide, and one foot deep,



Faster, better textile inspection

containing eight 40-watt fluorescent lamps. The face of the box is a large sheet of opal glass, which diffuses the light so completely that it is not possible to tell how many lamps are beneath it. Alternate lamps may be extinguished to reduce the brightness, without causing any noticeable shadows on the glass.

Lamps and ballasts are mounted on the back of the box, easily removable for servicing Installation is a simple matter of mounting the fixture where wanted and plugging the extension cord into a current outlet.

Standing in the "perch"—the textile industry machine for unrolling a bolt of cloth for inspection—the operator views the fabric as it passes over the "T-1" and he marks the cloth where defects are seen.

The fluorescent device is used for inspecting various types of cloth "in the gray," or before bleaching, dyeing, or printing. It displaces the two former inspection methods—viewing the cloth stretched across the face of a window

opening on the north for the sake of the relatively even "north light," and across a horizontal, flat bed using incandescent lamps.

The "window" type of inspection is unsatisfactory because the quantity and quality of natural light varies during the hours of a day, and even more because of weather and the changing seasons. It also is a bottleneck in war production because 'round-the-clock inspection is impossible.

The incandescent lamp apparatus increased the fatigue factor for employes because of heat and glare conditions, and where flat-bed tables were used, operators complained of cramped and stiffened muscles. The new device is easily set up in a slanting position.

MAGNETIC FLOW THEORY

Refuted on Basis of Experimental Evidence

THE RECENTLY revised theory of magnetic current—which if true would revolutionize century-old concepts of electricity—has been refuted by a Pittsburgh scientist who claims that rigidly controlled experiments have proved that magnetism does not flow in the same manner as electric current

Dr. Jacob E. Goldman, of the Westinghouse Research Laboratories, speaking before the American Physical Society, said that the experiments—conducted along the exact lines of those of Professor Felix Ehrenhaft, Viennese physicist and leading proponent of magnetic current—had produced conclusive negative results The age-old theory, held by nearly all scientists, is that magnetism has force and power, but no movement—unlike electric current in which electrons flow along a copper wire. Professor Ehrenhaft's theory that magnetic current can be generated by a permanent magnet, if proved correct, would mean the establishment of an entirely new source of power and would necessitate a complete revamping of currently held theories in physics.

A RESPECTABLE WEED

Is Being Used to Anchor Embankments

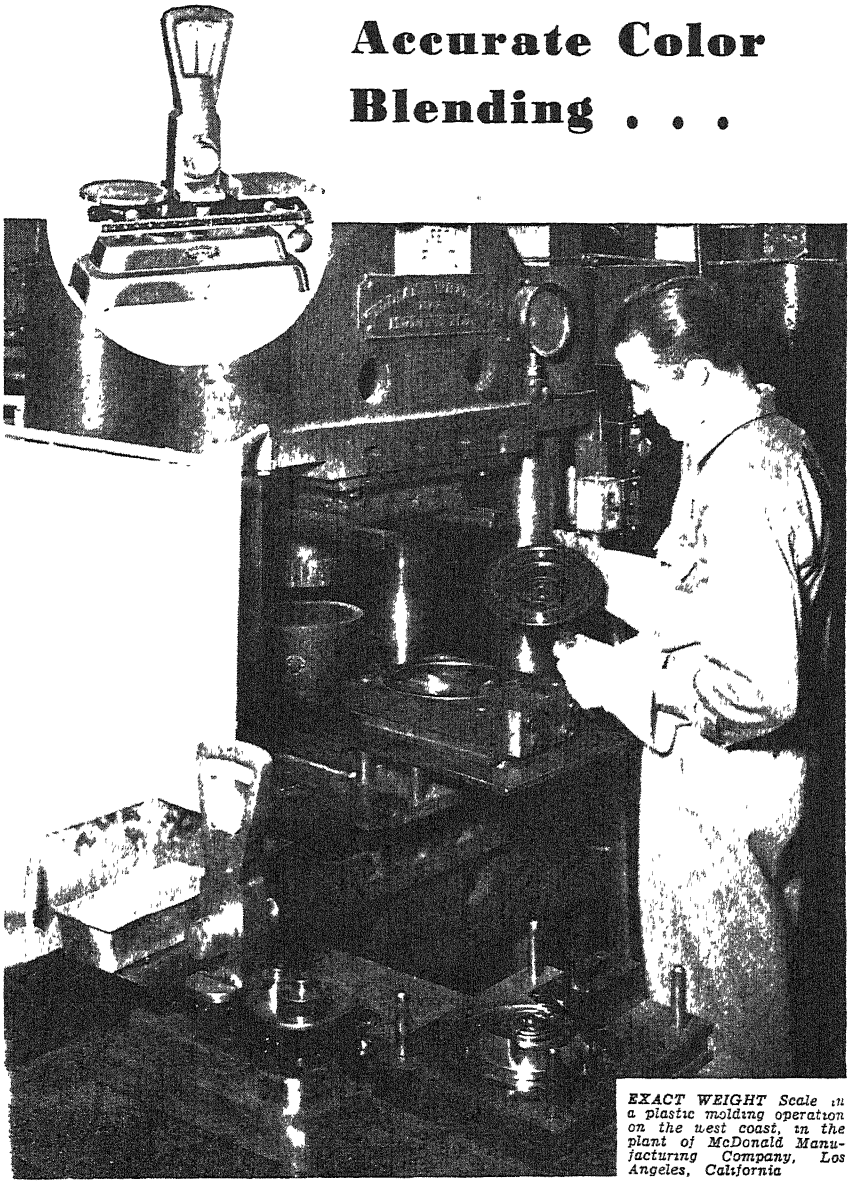
QUACK grass (*Agropyron repens*) is one of those weeds which get thicker and thicker and thicker as time goes by and become too coarse for a lawn. Once it gains a foothold, quack grass is not easily discouraged since it has an underground root system like a telephone cable. Every time a root is cut, a new succession of shoots are given an excuse to put in their appearance.

Thus far, quack grass has been put to at least two practical uses. In the northwest it has been assigned to the task of holding railroad embankments along the Columbia River and it has been used for airfield turf. It has been found to thrive in sections extending from North Carolina, Arkansas, and New Mexico, north to Newfoundland and Alaska.

Quack grass is hardly in a position to be chosen for agricultural preferment

for Plastic Molding Operations

Accurate Color Blending . . .



EXACT WEIGHT Scale in a plastic molding operation on the west coast, in the plant of McDonald Manufacturing Company, Los Angeles, California

Plastic ingredient compounding for molding operations is an exacting operation. So too is color blending for uniformity of product. Both operations require skill of course but much of this skill is a careful weighing operation in fraction ounces. This is an EXACT WEIGHT Scale operation of the highest type for industrial precision. These famous scales have been in the plastic industry since the first research laboratory days. Today this equipment can be found throughout the whole rapidly expanding field, coast to coast. Some models have been standardized for the industry, others specialized as ordered for such vital operations as ingredient compounding, color control and check-weighing finished molds for uniformity.
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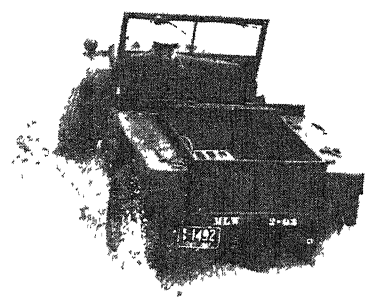
but it may have a future in areas where a tenacious turf is required and where dust must be kept down. For airfields, army camps, athletic fields, banks of streams to prevent erosion, and steep, uncultivatable hillsides in general, it might be the dark horse

SAND "JEEP"

Developed for Use by Coast Guard

A SAND-AND-SWAMP version of the "Jeep," which can carry eight men over soft beaches at 50 miles an hour, has been developed for Coast Guard patrol duty and personnel carrying in areas where the terrain is predominantly loose and sticky. The newest offspring of the Jeep, it is explained by Ward M. Canaday, president, Willys-Overland Motors, features a lower gear ratio than the standard model, this gives it greater efficiency on beaches and in swampland.



A beach-going version of the Jeep

The sand Jeep is 12 inches longer than its parent vehicle and has two inches more clearance It utilizes special jumbo-balloon tires which act as "snow shoes" on soft surfaces The new vehicle is equipped with a rotary hoisting device which enables the scout car to extricate itself or other vehicles from stubborn mud and sand The apparatus has a minimum hauling power of 2000 pounds when mounted on the front end of the Jeep, operating from its 63-horsepower engine.

The sand Jeep, which carries two men in the front seat and six in the rear, can lighten considerably the work of the Coast Guard in guarding long stretches of soft beaches, since it is virtually a rolling patrol station.

ASPHALT IN PACKAGES

Gives Advantages of Waterproofness and Adhesiveness

ASPHALT is commonly thought of only as a paving material, but actually it has many other invaluable uses, one of the most important of which is as a waterproofing and sealing agent in new types of packaging developed during the war.

The war has greatly intensified the demand for asphalt-laminated papers used in the walls of solid fiber containers for military and lend-lease items; as an outside lamination for waterproofness of paper containers for motor oil, paints, printing inks, and so on; for waterproof flexible films combined of kraft, metal foil, cellulose acetate, cellophane, and the like; and for treatment of sealing tapes Asphalt gives waterproofing comparable to that wax at about one tenth the cost and, in addition, is highly adhesive. One of its commonest current uses is in the thin laminated paper which has replaced metal foil as the protective inner wrapper in cigarette packages

The study of asphalt for packaging has become one of the major research projects of the year, and new uses constantly are being found —*Modern Packaging.*

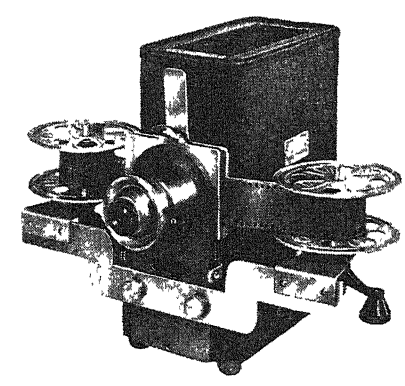
MICROFILM READER-PROJECTOR

Now Available in Compact, Portable Form

A PORTABLE microfilm reader-enlarger, weighing only 8½ pounds, has been released to industry and is now available.

In contrast to the usual library-type microfilm reading machines, this device is carried in a fitted case, like a portable typewriter It makes possible the study of microfilm records at one's desk, showing of microfilm enlargements of records, charts, blueprints, and so on, before groups, and opens up a great potential for the use of microfilm for inexpensive but effective sales presentations, engineering department drawing and specification study, employee training, and group instruction

This reader-projector, manufactured by Federal Manufacturing Engineering Corporation, requires only three or four feet projection space and permits 24-time magnification without loss of sharpness It is made to accommodate 35mm roll or strip microfilm In engineering design the instrument is exceedingly simple. Two thumbscrews unfasten the steel reel winder-holder



Portable microfilm reader-projector

Two more unlock the enameled main assembly case. Important feature of this microfilm reader is that it can be used for short length microfilm projection by unscrewing the reel holder. No special accessories are needed. Standard projection lamps up to 200 watt are used.

Chemistry In Industry

(Continued from page 66)

them immune both to insect and fungi destruction, a new chemical compound has been shown to increase potato crops as much as 25 to 100 bushes per acre, according to Rohm and Haas Company The "plant inoculation" possibilities of the new synthetic, known professionally as "diethylene-sodium-bisdithiocarbamate" and familiarly as "Dithane," were

Here is what the fungus known as "late blight" can do to potato plants. Dithane will control it

discovered by accident, and later tests proved it to be fatal to both chewing and sucking insects but harmless to plants and non-toxic to man.

In recent field tests in Florida and Texas, Dithane has not only proved deadly to such fungi menaces as late blight which swept many food-producing areas of the South last spring, but also made possible potato yields running from 25 to 100 bushels more per acre than plots sprayed with conventional fungicides. Further proof of this chemical's remarkable powers is revealed by the fact that it not only acts as a repellant to certain insects—unlike such standard fungicides as Bordeaux Mixture which actually builds up aphid infestations—but actually kills them. The serum-like effect of the chemical was discovered after unsuccessful attempts to grow beetles on a plot which had been sprayed with the experimental "fungicide"

PURE CELLULOSE

Needed in Large Quantities by the Rayon Industry

THE STEADY growth of the rayon industry has created an important market for agricultural and forestry products such as cotton linters and wood pulp, both of which are used to provide pure cellulose for rayon manufacture, it is pointed out by Louise Whitney of the American Viscose Corporation.

In 1943 the rayon industry used 55,000 tons of cotton linters pulp, equivalent to 237,000 bales of raw cotton linters, and 281,000 tons of wood pulp. The use of cotton linters is increasing, Miss Whitney says, because they are used in making the high-strength rayon yarns of the type used in tire fabric.

The discovery that southern slash pine could be used to produce pure cellulose, a result of the research work done by Dr. Charles H. Herty, created a new source of income for the South, according to Miss Whitney. The rayon industry is using increasing amounts of this cellulose, and reforestation programs insure a permanent supply.

Referring to the possibility of developing special types of cotton as a source of cellulose for rayon manufacture, Miss Whitney says: "The rayon industry's need for alpha cellulose offers some interesting prospects for chemurgic development Cotton is one of the best sources of cellulose and it has been thought possible that a cotton plant with a large concentrated boll that would be a super producer of cellulose might be developed"

INDUSTRIAL ENZYMES

Help Man to Improve Many Products

DEVELOPMENT of the wonder drug penicillin has focussed attention on a group of laboratory-cultured fungi or non-flowering plants similar to mushrooms which yield a group of mysterious and complex chemicals known as enzymes. These chemicals, whose name is derived from the Greek "en" meaning "in" and "zyme" meaning "yeast," are now performing miracles for industry similar to the ones they have wrought for medicine and their remarkable capacities suggest a host of new uses which have scarcely been tapped. Enzymes are "harvested" from the fungi and are today known to turn wood into sugar, sugar into fat, to help make buttermilk, cheese, beer, sweeter sugar syrups, clearer full-flavored wines and ciders, stronger textiles, and better leather and paper.

Normally enzymes work at the temperature of living organisms and, when used commercially, their actions can be stopped at will by raising the temperature of living organisms and, when done At the laboratories of Rohm and Haas Company, growers of industrial enzymes, the fungi are grown to form "seed" which are "sown" on appropriate mediums under carefully controlled temperatures, and finally "harvested." The culture is then dried, ground, and the enzyme extracted for commercial use Enzymes are soluble in water and insoluble in alcohol. Being catalytic in character, they speed-up chemical changes without themselves being consumed by the reaction.

Through the development of Pectinol enzymes, the muddy looking cider which used to appear around Halloween time has been largely replaced by a golden-colored, appetizing apple juice, free from discolorings and sediment. Other Pectinols have given permanent clarity to Concord grape juice and wines, and to blackberry, peach, and citrus juices. The enzymes leave the vitamin and mineral content of the original juice unimpaired.

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Roof Prism #5 - BS - $1.50 P.P. A few chipped but most were rejected because roof angle was off trifle more than two seconds. Excellent for most uses except for instruments of over 3 power

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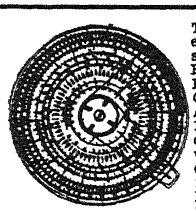

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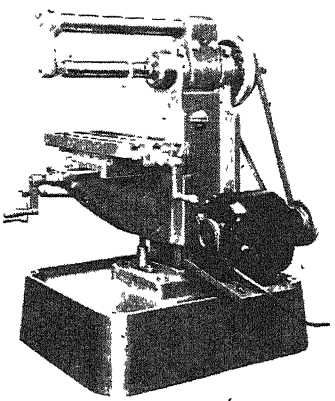
New Products

OVERARM

A REMOVABLE overarm that will greatly increase the versatility of combination, horizontal, and vertical milling machines has been developed by the Benchmaster Manufacturing Company. Consisting of three parts, this overarm makes it possible to use a regular milling machine arbor in a horizontal mill. It is readily mounted on the machine by removing



An easily attached overarm

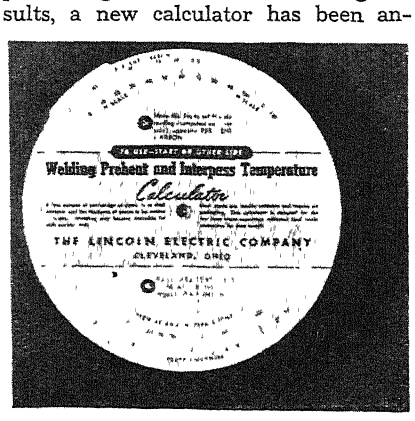
the driving pulley from the rear of the horizontal spindle, slipping out the spindle itself by releasing two accessible screws.

A heavy semi-steel casting is mounted on the horizontal spindle which holds a precision-ground stress-proof overarm carrying the outboard support. This attachment is desirable because it is very easily attached to the machine, and at the same time creates extra rigidity and support for arbors, boring bars, and special tools.

This new attachment can be used on old as well as new machines

WELDING CALCULATOR

DESIGNED for readily determining the welding preheating and interpass temperatures of steels in those few cases where experience indicates the need for preheating to obtain best welding results, a new calculator has been announced by The Lincoln Electric Company.



Temperature calculator for welders

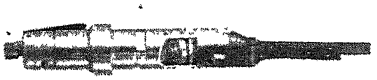
This useful calculator is 6¼ inches in diameter and consists of four movable sections of heavy cardboard stock. Complete instructions in the form of six simple steps are printed on the outside sections.

Although most steels are readily weldable and require no preheating because of low carbon and alloy content, this calculator will serve as a convenient guide in instances where steels have a higher content of carbon and other alloys and require preheating to minimize the tendency toward excessive hardening and possible cracking of the base metal adjacent to the weld.

FILING TOOL

A NEW pneumatic hand tool for doing fine finish filing in shops making die casting dies, plastic molds, and airplane parts, can also be used as a portable power saw for making irregular saw cuts by substituting a hack saw blade for the usual file.

The new filing tool includes a Keller rotary air motor together with a new cam and piston utilizing a ball-bearing assembly to transfer the rotary motion of the motor to the reciprocating motion of the file. The use of a



Reciprocating tool for filing

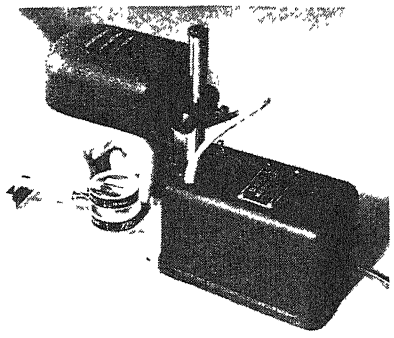
standard ball bearing set at an angle of 27 degrees with a cam angle of 25 degrees assures contact between the cam and the outer ball race, while the inner race is fixed to the piston and does not contact the cam surface. Wear on the cam and piston is thus materially reduced.

Being an air-operated tool, it runs cool even under heavy load and is therefore comfortable to handle.

This new tool is made with a free speed rating of 1500 strokes per minute and with a fixed length of file stroke of 7/16 inch.

FLATS AND MONOLIGHT

GREATER wearability and lower coefficient of expansion are reported features of the new DoAll optical flats made from fused Brazilian quartz which has a hardness of seven on the Moh scale as compared with six for optical grade glass. Six sizes are available, each flat being marked with accuracy guarantees showing variance in absolute flatness. They may be obtained with two grades of accuracy: one millionth accuracy for laboratory gage block and



Optical flats and monolight source

instrument inspection, two millionths for checking instruments and fine tools.

These optical flats, used with monochromatic light, provide industry with the greatest accuracy for making fine measurements. For a monochromatic light having large adjustable capacity as well as compactness, the same manufacturer offers the DoAll Monolight using a helium-filled tube to give yellow light of one wavelength only. The light is high in intensity which concentrates the light on a smaller area, giving greater illumination for distinguishing the light-wave unit known as the "fringe" or interference band.

PRECISION MANOMETER

A NEW mercurial manometer has a wide variety of uses, functioning equally well as a manometer, barometer, differential pressure indicator, and differential vacuum indicator. Among its advantages is the speed and ease with which observations can be made, giving it special utility in the chemical industry. In infra-red spectroscopy, it has proved superior to instruments of conventional design It is especially well adapted to checking and calibrating aneroid instruments

Full temperature compensation over any selected range of 30 degrees, Centigrade, is easily obtained by setting a graduated, knurled nut to the ambient temperature, thus doing away with the need for applying temperature corrections to scale readings. Another feature is a new type indicator. A thin, horizontal steel disk is mounted on top of a stainless steel float which rides on top of the mercury column The thin edge of the disk gives hair-line indication.

Readings, accurate to the nearest tenth of a millimeter, are made possible by a built-in, focusing magnifier.

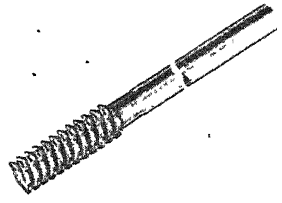
HYDRAULIC TESTERS

A NEW line of machines which test all types of production hydraulic devices and components, and which fill, filter, and check hydraulic systems, comprises various types and sizes, including stationary and portable models, driven by gasoline or electric motors.

Four types of the machines, which embody novel features, are announced by Greer Hydraulics, Inc. Model HS101 is designed for inspection and operational testing of any single or complete line of hydraulic components, and for research and development testing. Model HS100 was developed specifically for testing airplane hydraulic systems and their components. Models HS102 and HS105 are both portable, and are designed for testing airplane hydraulic systems on the final assembly line or on the field.

ROTARY BROACHES

A TOOL that is in effect a broach that rotates as it cuts, makes possible the production of perfectly round holes. The Shearmaster "Rotary Broach" removes metal by a true shearcutting knife-like action, and the chips resemble steel wool in form and texture. Because the cutting edge is in the form of a circle, there is no tendency to produce elliptical or uneven holes. These broaches, it is said, may be sharpened from five to thirty times before they wear under-size. They are being marketed with straight shanks only in sizes from ¼ to 1 inch by sixteenths, and from 1⅛ to 1½ inches by eighths.



For making perfectly round holes

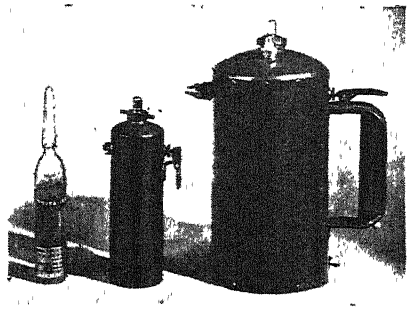
Larger sizes up to six inches can be supplied on special order.

Shearmaster "Rotary Broaches" may be used in any machine to take the place of a reamer, but should always be mounted in a floating holder in order to secure the accurate holes that are produced when the tool is properly used.

LENS CLEANING

A SIMPLE system for cleaning goggles, glass faced dials, microscope and inspection lenses, and so on, in industrial plants includes hermetically sealed ampoules of Brite-Ize Concentrate, each of which when mixed with distilled water makes a gallon of lens cleaner, and "cleaning-station" dispensers.

Brite-Ize is a detergent which removes fog, grease, grime, and splatter instantly; leaves no halation; will not injure rim plating, leather, fabric, or rubber mountings It assures maximum vision and sharp clean definition By making lens cleaning easy, it encourages workmen to keep goggles clean with resulting improvement in work,



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INTERNAL GRINDER

WHAT IS said to be the first internal grinder to utilize a combination of hydraulic operation and electric control has just been announced by Sav-Way Industries

Outstanding features are short table stroke—5/32-inch minimum—and extremely rapid table feed and reverse which combine to give the machine almost machine-gun speed on short work

Solenoid operated valves and aircraft type micro-limit switches provide constant control and reduce time lag to a negligible minimum.

In addition to electro-hydraulic control, the machine is also equipped for

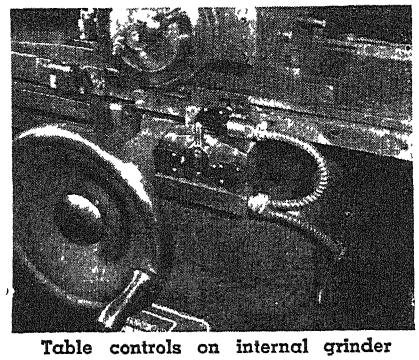


Table controls on internal grinder

hand table feed, a time-saving convenience when setting up. The hand feed is engaged by moving the hand wheel out to engage a rack and pinion To disengage the hand feed, the hand wheel is pushed in.

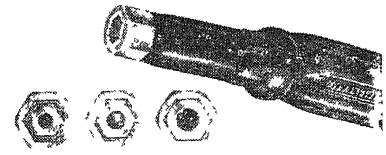
WELD TIMER-CONTACTOR

COMBINATION timer-contactor "package" units designed to provide simple, low cost, automatic, electronic control for resistance welders may be used with new machines or to convert manually or cam-timed welders for electronic control. When used with air or hydraulically operated welders, the new "package" units eliminate inter-unit wiring, simplify installation and maintenance, and permit mounting of all controls on a machine if desired.

Ignitron contactors in these Weltronic units provide high current capacity contacting at practically unlimited speeds for the most critical welder operations such as welding thin sections and aluminum or aluminum alloy metals.

THREE-IN-ONE WRENCH

HAVING the same approximate dimensions as a single socket wrench and but little additional weight, the new Tesco multi-socket wrench automatically accommodates No 10 standard, No. 12 standard, ¼-inch standard and light, and 5/16-inch light hexagon nuts. Merely by pressing the wrench over any of the three sizes of nuts automatically selects the correct nested hexagonal tube suited to that nut



Three socket wrenches in one

This wrench is designed for heavy-duty service, making it available for factory production or servicing work of any kind. Its design is such that any stress incident to turning a nut is transferred to the outer hardened-steel casing. It is also designed to provide a clearance through the barrel for studs up to 5½-inch length

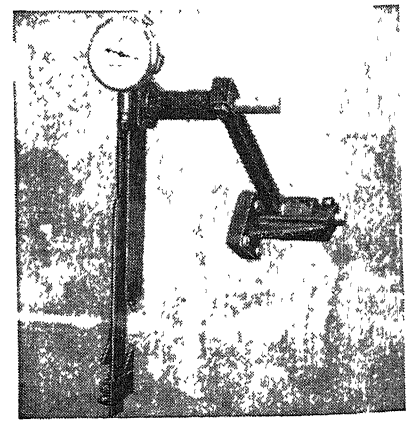
REFRACTOMETER

REFRACTIVE index provides a means of controlling many processes in the food, petroleum, chemical, and other industries Very little material is needed to obtain a refractive index reading and results are obtained immediately Now there is available a new Spencer refractometer which, because it has no compensating prisms, is used with a monochromatic light and provides an extremely sharp dividing line which promotes accuracy in use. Scales read the refractive index directly when a sodium vapor lamp is used with the refractometer Special correction charts are used when a mercury vapor lamp or hydrogen discharge tube is employed as the light source.

GRINDING GAGE

ACCURACY and speed in precision grinding operations can be increased with the new visual grinding gage illustrated here The gage is applied to and taken off the work while the machine is in operation, and "miking" is eliminated. The dial indicator guides the operator as the work is ground to size The gage indicates the correct size even though the sizing controls of the machine may be worn Grinding tolerances of plus or minus .0001 inch are easily maintained.

The Stuart Micromatic gage has no gears, levers, or angles, the dial being

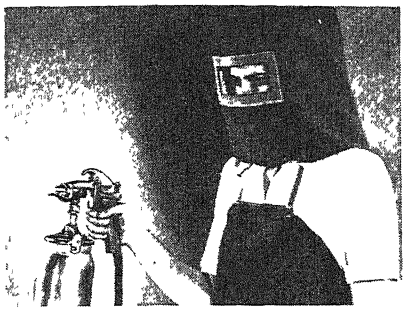


Reading of the dial indicator acts as guide during grinding operation

actuated by direct parallel thrust Contact points of the caliper measuring bar are of tungsten carbide for long wear.

PROTECTIVE HOOD

A LIGHTWEIGHT, air-supplied hood to protect workers in paint, chemical woodworking, metallizing finishing, and allied industries guards the eyes. ears, face, neck, and respiratory organs from harmful and irritating substances, mists vapors, fumes and dusts It is designed to afford safety. comfort,



Safety and comfort on the job

and freedom of body movement and to allow easy replacement of all parts This pliable hood weighs only slightly more than a man's felt hat and is fitted with replaceable forehead pads

Compressed air at low pressure, from the same supply used to service a spray gun or similar equipment, is fed into the hood through a distributing tube which is held in position at the operator's waist by a belt clip. A removable diffuser allows the air to expand and discharge at the top of the hood from where it floats down over the operator's head.

DETACHABLE COUPLING

A DETACHABLE brass coupling for helical flexible metal hose in sizes from ¾ to 1½ inches inside diameter, offers the advantage of being mechanically self-sealing No brazing is employed—no heating of the hose to weaken it at the point where flexing and vibration place the greatest strain on the hose

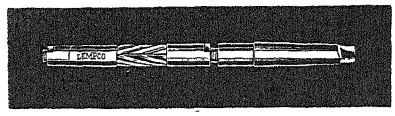
The unit consists of only four parts —the nut, back, stem, and split ring. When assembled, the convolutions of hose and the metal braid are securely held by pressure between the members

The coupling withstands pressure tests of up to 800 pounds

A further feature of design, developed by Packless Metal Products Corporation, is the self-contained union which permits the pipe thread end of the coupling to be screwed directly into the machine fitting and the union tightened without twisting the hose

EXPANSION REAMER

AN ADJUSTING lock-nut is used to hold the three cutting blade segments absolutely rigid in a new Lempco high-speed expansion reamer. This prevents any possibility of an oversized bore resulting even when the reamer blades are subjected to excessive pressures. Of the three blade segments, two spiral



Reamer blades are rigidly locked

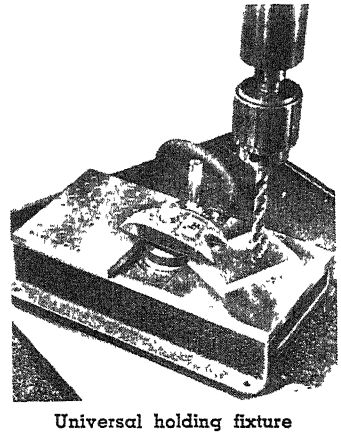
simultaneously in a direction opposite to that of the third This opposite-spiralling effects a shearing action which finish-reams mirror-smooth any machinable metal ferrous or nonferrous, as well as laminated phenol-formaldehyde and other fibrous plastics ordinarily difficult to machine smoothly

The removable blades are quickly and economically resharpened They maintain their size and keep cutting edge much longer than ordinary reamers because from 035 to 080 inch straight-line expansion is provided

"FLAT TOP" FIXTURE

HOLDING small flat work for toolroom use and certain other types of production operations is accomplished with a simplified fixture recently announced by Mead Specialties Company It was developed to overcome difficulties encountered in drilling, countersinking, and tapping small precision parts in which highly accurate perpendicularity was essential

This fixture is instantly ready to



Universal holding fixture

hold any type of work which is flat on the bottom, varying in thickness from a few thousandths up to a couple of inches, and in area from the size of a dime up to several inches square. The

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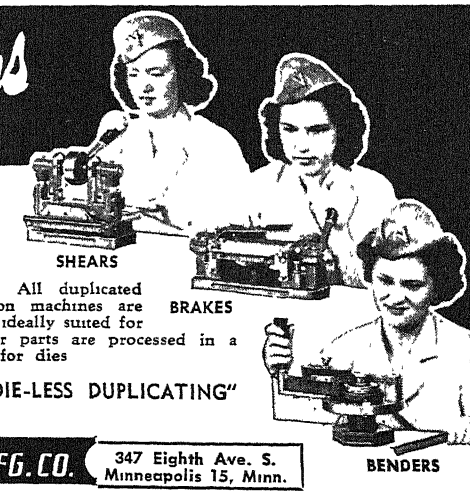

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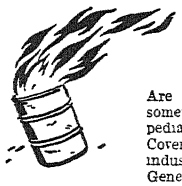

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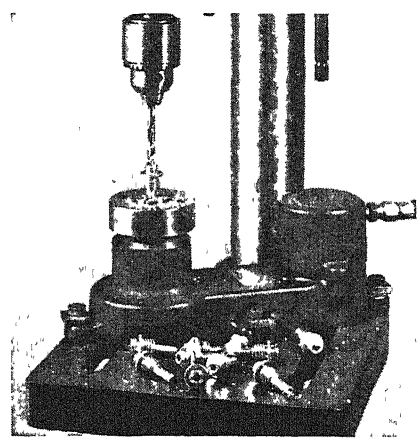
peripheral contour of the work makes no difference.

But the utility of the 'Flat Top' fixture is not limited to drilling and tapping operations alone. It is also useful for many operations on small shapers and bench milling machines. One of the supporting plates is perforated and provided with three studs. This end of the fixture is used for milling and shaping work. Two studs are set in position to locate the back of the work, and the third is set at the end to support the work against the pressure of the cutting tool. This arrangement automatically makes a high-speed precision fixture for production work. The "Flat-Top" is a universal jig which can be changed from one set-up to another simply by dropping three studs into three holes.

COLLET AIR CHUCKS

NEW MODELS of an air-operated chuck have a collet capacity up to 1¾ inches. These models also use Brown and Sharpe type screw machine collets



Air pressure actuates this chuck

by which work can be held to center and depth. The collet remains stationary, thereby eliminating any possibility of variance due to variations in the diameter of the parts to be held.

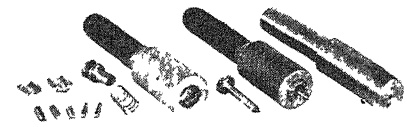
The Redmer air chuck is a precision-holding fixture for holding parts for milling, drilling, tapping, threading, assembly, and so on, and eliminates in many cases the making of special fixtures.

SHAFT MARKING

DESIGNED expressly for marking the ends of shafts and other parts having a center hole, an improved steel type holder (center of illustration) which may be used either with individual type or with logotypes made to specifications of the user has been developed by New Method Steel Stamps, Inc. End marking is often desirable, since the end of a shaft or other part is frequently visible when the outside surface is enclosed in a housing or is otherwise poorly exposed.

When furnished with a knurled shank the holder is used for hand stamping, and with a turned shank it may be mounted in a press.

The holder is equipped with a floating locating pin backed up by a light



Marking device for shaft ends

spring to insure proper register of markings around the center. Individual steel type or logotypes (lower left of illustration) are made in tapered segments to form the proper radii.

PLASTIC PREHEATER

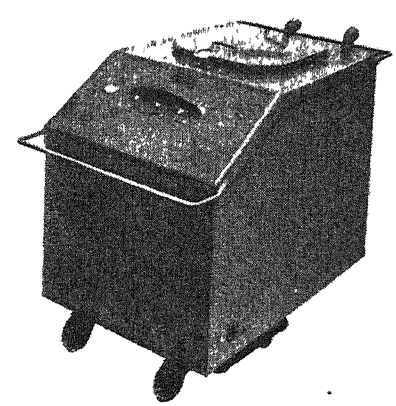
PLASTIC preheating time is reduced to a matter of seconds with a new machine designed specially for easier, faster preheating of plastic preforms—wood flour, rag, and mica filled phenolic.

The heating is done between plates which are built into the cabinet of this Illitron unit. The plates are opened to receive the preforms and closed for heating, similar to the operation of a waffle iron. These plates are self-adjusting to accommodate preforms of various thicknesses. The movable plate has a heat retainer which maintains the temperature in the preform after the high-frequency heating is off, so that greater time is permissible between the pre-heating and loading of the press. An automatic timer cuts off the heating after a predetermined time and simultaneously turns off a light on the panel board. A meter indicates in watts the amount of heat per second that is generated in the preforms, so that a close temperature control can be maintained.

A manual adjustment can be made whenever the operator changes from one type of preform to another, and a marking on the heat-rate meter will indicate the correct adjustment for the change to be made.

PORTABLE HEATING TANKS

ONE of the many types of special heating tanks for industrial uses, now being built by the Youngstown Miller Company, is a portable unit which consists



Heater for special shop jobs

of an insulated heating tank equipped with electric heaters, a motor and pump for circulating the oil, thermostats for maintaining the oil temperature within certain limits, and complete with electric controls and valves.

Current Bulletin Briefs

Conducted by K M. CANAVAN

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below)

B. F GOODRICH BRAND INDUSTRIAL RUBBER CLOTHING is a four-page catalog section which illustrates and describes their fire coat, general purpose work coat, double back industrial coat, standard police coat, universal work pants and jacket, workers' leggings, work 'n weather hats, and aprons—all coated with rubber or rubber-like materials *The B F. Goodrich Company, Akron, Ohio —Gratis.*

OCCUPATIONS IN PLASTICS is a six-page folder outlining 15 different jobs in the plastic field that offer possible postwar employment. Also presented is information on average earnings, principal manufacturing areas, methods of getting a job, and the abilities and preparation required *Occupational Index, Inc., New York University, New York 3, New York.—25 cents.*

WOOD'S TECHNOLOGICAL COMING-OF-AGE is a booklet which reviews many new wood derivatives and modified wood products. Included are Impreg, Compreg, Hydroxylin, Papreg, and Uralloy Request Report 1442 *Forest Products Laboratory, Madison, Wisconsin —Gratis.*

WAXES FOR TODAY AND TOMORROW is a booklet which affords a ready reference for production men and which lists 36 different kinds of waxes with their specifications and prices *Distributing and Trading Company, 444 Madison Avenue, New York 22, New York. —Gratis.*

CONVERSION TABLES FOR RAKE ANGLES is a 16-page manual on sharpening milling cutters, gear hobs, and so on It contains tables of offset distances for rake angles in 1 degree steps from 1 to 25 degrees A formula is given for the computation of special angles, also many helpful suggestions on grinding, set-up, and the prevention of run-out *Detroit Tap and Tool Company, 8432 Butler Street, Detroit 11, Michigan — Gratis.*

HOW TO PUMP IT is a 20-page catalog giving complete information on several Rex pumps—their construction and operation. With capacities of from 3000 to 125.000 gallons per hour, they are useful in many different industries. *Chain Belt Company, 1600 West Bruce Street, Milwaukee, Wisconsin.—Gratis.*

POWER CENTERS is a 25-page booklet presenting a guide to the selection and specification of power centers which, combining transformer and switching material in one unit, save time, labor and critical materials. Minimum space requirements additional safety, and other advantages are listed. Request Booklet B-3224 *Dept. 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.—Gratis*

STANDARD METHODS FOR THE SAMPLING AND ANALYZING OF ALUMINUM AND CERTAIN ALUMINUM ALLOYS is a book containing tested and proved chemical methods for the determination of various elements in aluminum alloys *Aluminum Research Institute. 111 West Washington Street, Chicago 2, Illinois —70 cents.*

HOW TO USE FLUORESCENT ACCESSORIES FOR BEST LIGHTING RESULTS is a 16-page catalog giving technical information on three auxiliary devices—the lamp-holder, the starter, and the ballast—with illustrations and descriptions of each Several pages are devoted to the Watch Dog starter *General Electric Company, Bridgeport 2, Connecticut.— Gratis.*

YM ROBOT REFINER is a four-page folder which describes, with the aid of a flow chart, this improved oil reclaimer which is automatic and continuous. This unit removes fuel dilution, acids, solid and colloidal carbon, dirt and similar matter, as well as restoring emulsified oils Capacities range from four gallons per hour to 300. *The Youngstown Miller Company, Sandusky, Ohio.—Gratis*

HOW TO DESIGN A BUSINESS FORM is a 16-page booklet which discusses the use, design, nature, and improvement of business forms together with many suggestions and a handy form-check *Hammermill Paper Company, Erie, Pennsylvania —Gratis.*

DUPLEX TUBING is an eight-page bulletin on the applications of this tubing, developed to overcome corrosion problems, with cross-sectional views showing different methods of installation *Bridgeport Brass Company, Bridgeport 2, Connecticut —Request this bulletin on your business letterhead.*

JESSOP STAINLESS-CLAD STEEL is a catalog which contains information on the applications, manufacture, fabrication, styles, and sizes of this stainless-clad steel. *Jessop Steel Company, Washington, Pennsylvania —Gratis.*

THE STORY BEHIND THE TURNER BRASS WORKS is a 16-page booklet outlining the history of the company and its war record, with illustrations of some of its war-time and peace-time products *The Turner Brass Works, Sycamore, Illinois.—Gratis.*

CEMENTED CARBIDE TIPPED CUTTING TOOLS is a 48-page catalog outlining types and specifications of many carbide tools, including spiral reamers, side milling cutters, router bits, boring tools, jobber reamers, and others. *Wendt-Sonis Company, Hannibal, Missouri.—Request this catalog on your business letterhead.*

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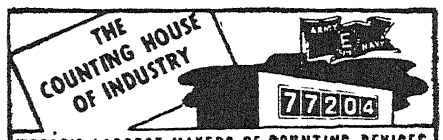

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OFTEN this department is asked for instructions for making a binocular No such thing exists, nor would the job be very simple on a single instrument Quite the contrary The optics would be those of two refracting telescopes of short focal ratio, plus two Porro prism systems which erect the image, shorten the tube and, by encreasing objective separation, enhance the stereoscopic effect (the dear public largely thinks they are put there to magnify); plus a mounting In time and money, too, the job would far outcost a purchased instrument, and thus is practically impracticable That is just why some enterprising, nose-thumbing amateur will ultimately make a binocular While the following résumé of recent improvements in U. S. Army binoculars, which was obtained from Frankford Arsenal, Army Ordnance Department, gives no how-to-make-it instructions, its background data should interest all readers

THE EMERGENCY precipitated by the impending World War II presented the United States Army Ordnance Department with the problem of immediate procurement of a large quantity of binoculars Because of the urgency for setting up production it was necessary to select the most adaptable model for which tooling existed and to produce approximately 350.000 instruments as quickly as possible The model selected was the 6 × 30 commercial binocular being manufactured by the Bausch and Lomb Optical Company with whom an initial order for 20,000 binoculars was placed This binocular was given the official nomenclature "Binocular, M3," indicating Standard Army Issue model No. 3 in the 'M" series of binoculars The 6 × 30 denotes six power magnification and 30mm objective diameter.

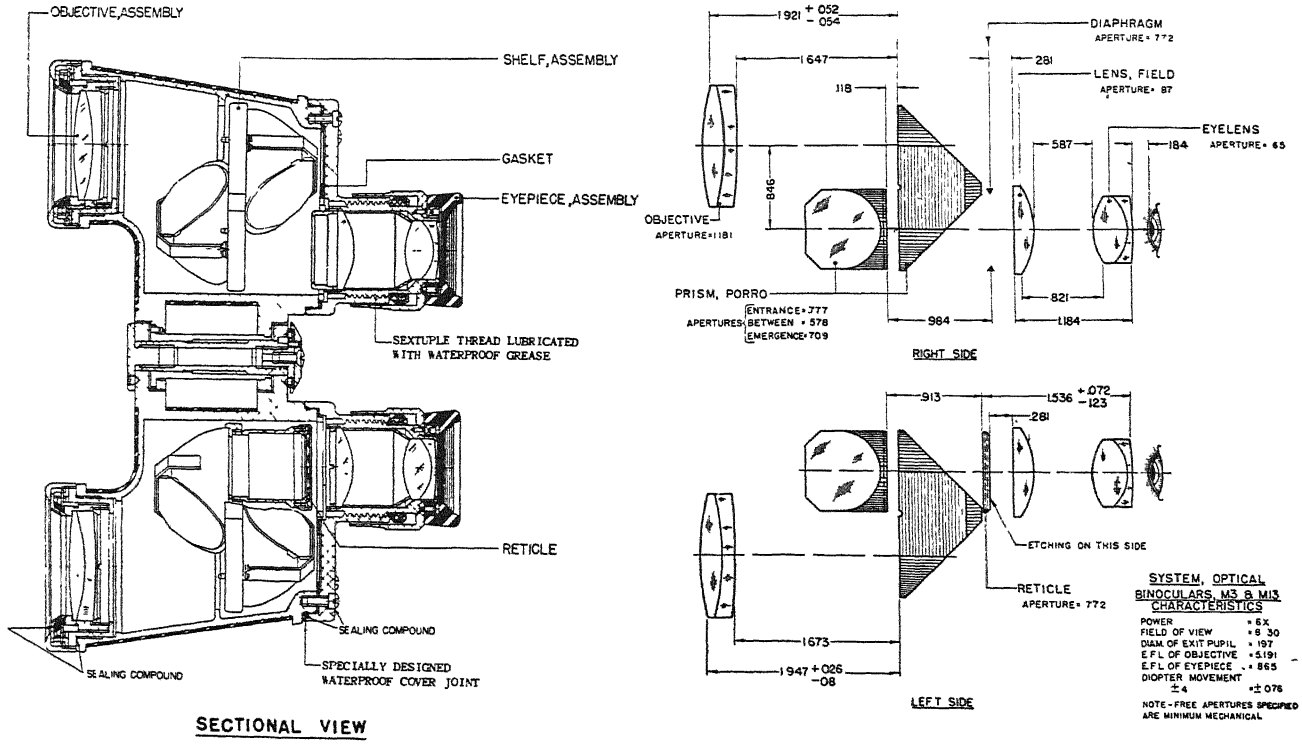
The only change necessary in the commercial model was the incorporation of a military reticle. The reticle shown below is a glass disk, both surfaces of which are polished parallel to within two minutes of arc On one surface lines and figures, presenting a graduated scale, are etched and filled with an opaque material to make them visible The crossline pattern and the dimensions of the reticle are determined by the type of binocular in which the element is to be used The element is usually made of baryta light flint or spectacle crown glass. The function of the reticle is to place the crossline pattern in the same focal plane as the real image formed by the objective so that the distance between two points or objects in the field of observation may be calculated

Since it was apparent, even prior to placing the initial order, that the resources of the experienced Bausch and Lomb Optical Company would be necessary for the production of more critical precision optical instruments than binoculars. arrangements to set up separate facilities to produce binoculars, solely and on a large scale, were inaugurated Nash-Kelvinator, Ranco Division. and Westinghouse Electric and Manufacturing Company were selected on the basis of Industrial Service surveys indicating their ability to utilize their existing equipment.

As neither Nash-Kelvinator nor Westinghouse had previous experience in making military optical instruments or the facilities for the manufacture of the optical elements, the Ordnance Department instituted an elaborate program for procurement of the essential optics to be furnished to the two companies for assembly with the mechanical elements into complete binoculars Optical elements included in the binocular are Porro prisms, spherical lenses, cemented doublets—that is, a crown and a flint lens cemented together—and a reticle The complete assembly is shown below

Fortunately, binocular optics do not require the extreme accuracy of optics such as Amici prisms and other special elements used in higher powered instruments

Despite the fact that optics were being manufactured by approximately 50 different companies, surprisingly little difficulty through rejections and disputes between the optics processors and the instrument assemblers was experienced This may be attributed largely to an efficient inspection system. Inspectors especially trained at Frankford Arsenal for inspection of fire control instruments were sent out to each one of the 13 ordnance districts in the United States Since inspection of an optical surface cannot be measured with a graduated instrument, but



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must be based on the judgement of an inspector, occasional controversy arose regarding acceptability In such case, a standardization meeting was held, whereupon master inspectors from Frankford Arsenal rendered final decision

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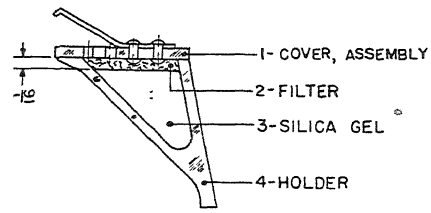

DESICCATOR, ASSEMBLY

Seas, in the icy climates of Greenland and Alaska, and in the African desert where night temperatures are below zero in sharp contrast to the extreme heat of the day Binoculars used in World War II are subjected to terrific vibration and shock in transport and in action and often are completely immersed during military surf landings From the viewpoint of World War I, Binocular M3 is a superlative instrument. However, after a quantity of the M3 binoculars were issued and in use, many difficulties due to the nature of military operations of World War II were reported.

As a result of these reports, a concentrated study of the most minute details of Binocular M3 was conducted, which eventually resulted in the development of Binocular M13

The first problem to be considered in the development of the M13 from the basic M3 was that of waterproofing the instrument to withstand submersion This was accomplished by redesigning the cover plates to provide for the use of a synthetic rubber gasket and a greater number of fastening screws In addition, a new military wax, capable of withstanding extreme high and low temperatures, for sealing the objective lens and objective assembly was developed by the Ordnance Laboratory This compound, Specification FXS, replaces Navy Black Sealing Compound No 3A. It resists cracking at —50°F. and has a melting point of 210°F, as against 150°F for No 3A compound The formula includes a fungicide to repel molds and insects

Shock and vibration tests revealed that severe shock caused shifting of the original prism mounting, affecting the optical alinement of the instrument Experimentation with methods of mounting prisms resulted in the use of a dental cement This cement is a blend of cupric oxide powder. phosphoric acid, and zinc chloride in solution. The ingredients are mixed in the ratio of three parts of powder to one part of liquid. Additional tests proved that prisms mounted with this agent were locked firmly against all shock, remained free of strain, and could be removed readily for cleaning.

Another very serious problem, applicable to all telescopes, was the formation of moisture on the optical elements within the finished instrument In any binocular, moisture may eventually enter and condense on the optics, because no instrument with an adjustable threaded eyepiece movement can be sealed perfectly Such formation is most objectionable on the graduated reticle, upon which the most trifling speck is visible and distracts the user A plane high in the sky first appears as a tiny pinpoint which looks very like a fleck of dust under the magnification of the binocular eyepiece

Experience gained in packaging complicated items for export, using dehydrating agents, was utilized in solving this problem A special cartridge, shown in the small illustration, containing a small amount of silica gel, was placed within the body of each binocular. The instruments so treated were tested by subjection to most adverse conditions of humidity and rapid changes in temperature, which proved that the desiccant eliminated formation of moisture on the optics over an extended period of time

A means of making the binocular more usable under conditions of fading light was undertaken. American binoculars effective an hour later in the evening than those of the enemy would be of great advantage to American soldiers Therefore, a development of the optical industry—coating optical surfaces with a magnesium fluoride film to reduce loss of light by reflection—had been under study by the Army and Navy for some time By exerting the full power of research of the Army, Navy, and associated commercial facilities toward perfection of magnesium fluoride and other coating techniques, coatings were produced to withstand cleaning and all field conditions The magnesium fluoride coating is applied to the optical surfaces at high temperature under a high vacuum, the fluoride becoming a part of the glass surface. This coating reduces light reflection and permits a greater amount of light to pass through the optical system, enabling the use of the binocular at dusk, when light is fading.

After the time and money spent in producing a fine binocular, an improvement in the export method was incorporated as further insurance that the binocular will reach the ultimate user in factory-new condition The binocular is placed in its special leather carrying case and sealed, together with five ounces of silica gel, in a moisture-vaporproof bag and cushioned in a corrugated carton Twenty-four such cartons are then packed in a steel-strapped wooden box having a submersion-proof bag lining

This new M13 binocular is now in mass production Thousands of them are being shipped every month to American fighting men overeas to aid them in seeing the enemy before the enemy sees them. Of course, the Ordnance Department is never satisfied with the degree of perfection of the fighting equipment of our Army. Even now, additional improvements to assure that the American binocular is the best in the world are in progress.

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COVER Symbolizing the tremendously destructive force of vibration in machinery, the picture to the left on the cover is a double exposure, made purposely to dramatize the effects of uncontrolled and unleashed vibration Since vibration cannot usually be completely stopped, the next best thing to do is to isolate its effects. The article on page 118 tells how.

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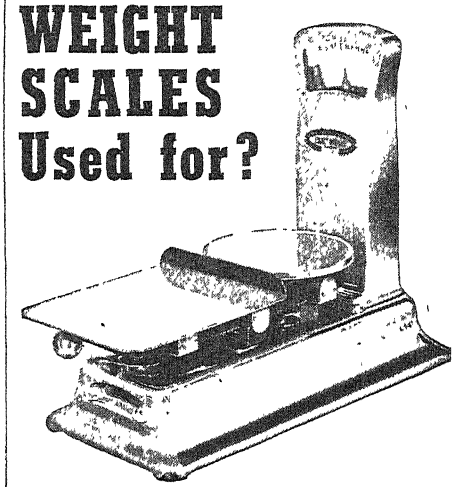
Exact Weight Scales

What are EXACT WEIGHT SCALES Used for?



In one short month, one industry alone, the metals industry bought EXACT WEIGHT Scales for the following operations: abrasives, grains, tube parts, nuts and bolts, snaps, powdered metal, aircraft propeller packing, laminations, blade bushing, grease in bearings, precious metals, stoker blade castings, connecting rods. These operations included parts counting, testing, balancing, and ingredient compounding. Every month we sell these famous precision industrial scales for more and more different uses . . . proof we believe that doing it by weight is more accurate and faster. Write for details covering your problem.

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Previews of the Industrial Horizon

By A. P. Peck

WHAT ABOUT PREFABRICATED HOUSES?

THE ESTIMATE of a potential demand for one million private dwellings per year for at least five years after the war (this page, February 1944), still holds. If the building industry meets this demand, it will climb to a peak considerably higher than ever in the past But there are many problems that must be solved first and not the least of them is the economic one of funds available by the average prospect for a new home versus increased labor costs that will undoubtedly remain at high levels after the war

Some people look to the prefabricated-house industry to furnish a large part of the answers. Let's glance first at the cost of the labor that goes into the construction of a moderate cost home. Reliable figures show this to be only about 8 percent of the total purchase price So, from a labor standpoint, prefabrication has only a small part of the whole to work on. Then it is found that the building itself, the "rough and finished structure," accounts for only 47 percent of the purchase price, and this includes the cost of labor on this part of the job. Since prefabrication cannot affect land costs, street improvements, excavation and grading costs, and the like, it can be expected to prove its worth on only a part of the total problem

The probabilities are that the advantages which prefabrication can offer to the industry and the home buyer will be summed up in better houses for a given cost rather than greatly lowered cost for a given quality Production of unit wall and roof sections, of standardized bathrooms and kitchens, of insulating procedures and heating equipment will first make available soundly engineered homes at minimum cost for architectural consultation. Then, when such production can be placed on a mass basis and a demand can be created, there can come "production-line" economies that will have some effect on final costs.

Considering every side of the question, however, some of the claims of the advocates of prefabrication must be taken with a whole shakerful of salt. When they talk of savings up to 50 percent of the total, they are talking through their hats. But when they point out that, through prefabrication, homes can be quickly erected, wall surfaces can be prefinished, sturdier homes can be provided where required, they have points that are worth studying.

But, lest the deep-end beckon too strongly, it must be remembered that the horizon of prefabrication will not glow with a bright, rosy hue until mass buying makes mass production a possibility

CLEANER PLANTS

IF WAR-NECESSITATED industrial plant construction has done nothing else, it has brought home forcefully the fact that clean plants, attractively designed, tastefully landscaped without and decorated within, are worth the slight extra cost and trouble that these features entail. Community pride is developed thereby, workers are happier, and the overall picture is brighter.

Industrial engineers are heeding this trend, foresee its spread to post-war remodeling of existing buildings. Included will be more attention to personal facilities for employees, dust and dirt elimination and collection, air conditioning, and other details that will react to the benefit of all.

AIR TRAVEL TOMORROW

IN ALL the talk of post-war weekends in China, mid-week excursions for big-game hunters in Africa, and all the other possibilities of commercial aviation tomorrow, let's not get too far ahead of ourselves. The aviation industry is going to make great strides in passenger carrying. That much is beyond question. Speed of air travel is going to climb far beyond that of pre-war aviation, airports are going to be available all over the world, aviation will be less affected by weather. But air travel is still going to be expensive except where time is of great importance The average vacationer and pleasure traveler will still be largely earthbound, depending for transportation on motor car, train, and ship This is not to say that the airlines will not be patronized. They will. But they will not, at least for a long time to come, carry more than a small fraction of the traveling public.

COLD IN THE HOME

ONE COMPANY that is planning to get in on the ground floor of a relatively new industry after the war is Westinghouse Already they are conducting field tests on types of freezing units for home use, designed not only to freeze home-grown foods but also to keep commercially frozen foods for extended periods of time

Such freezing units will tap a new market, a market already conditioned by the spreading use of frozen-food lockers And the extensive use of freezing units in the home will make many changes in the whole food industry. Foods will be more generally bought in large quantities for storage until used, necessitating revision, to some degree, of distribution methods. All in all, home freezing units have a bright future and one that should be closely watched for its effects on other industries.

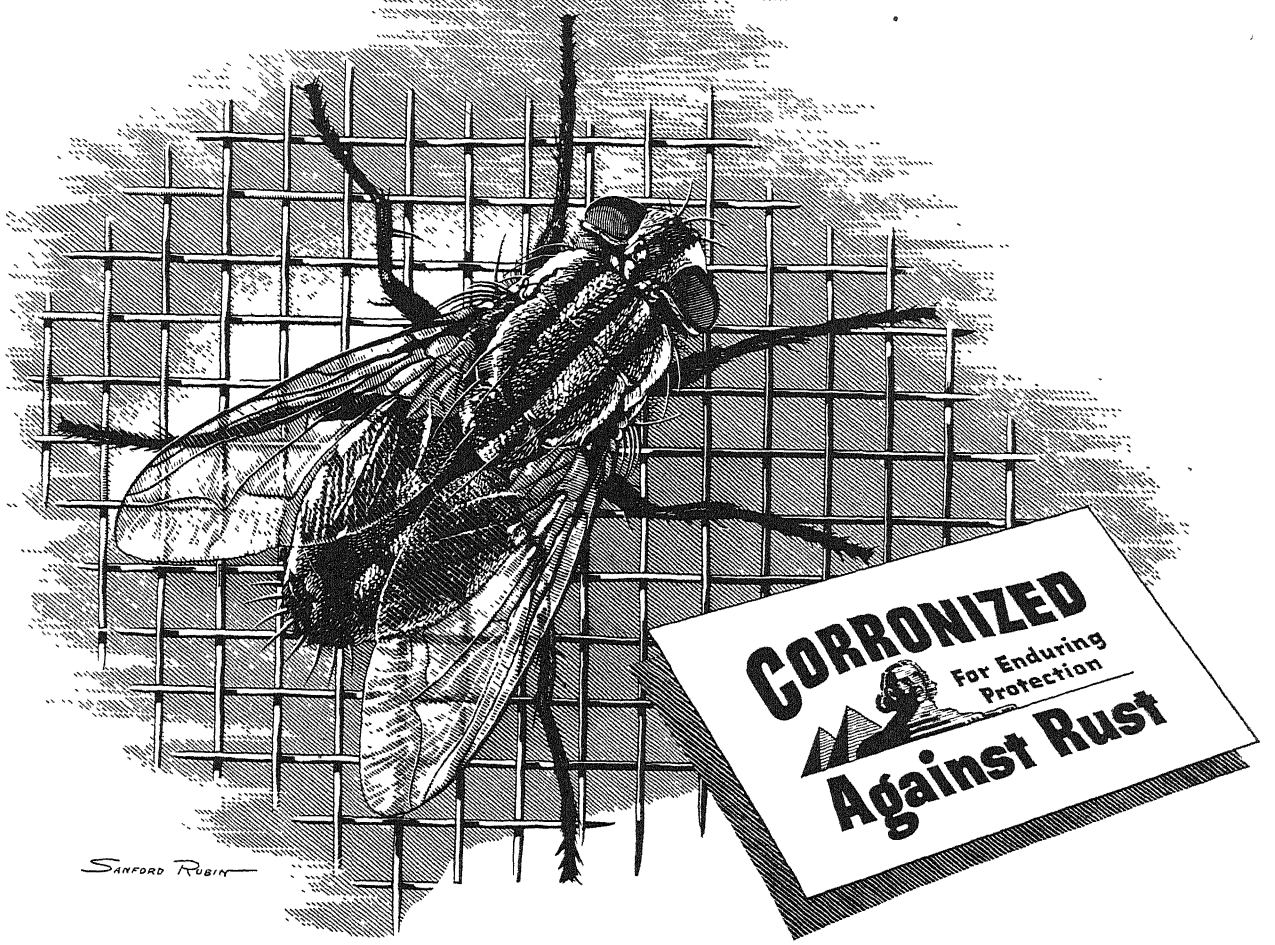
WOOD AND FURNITURE

IF THE Wood Office Furniture Institute has anything to say about it, metals, plastics, and other materials are not going to take much of the market away from that part of the industry which they represent. Already post-war models of desks and chairs have been produced, featuring improved design, adaptability to persons of different sizes, adjustable footrests, suspension-hung drawers moving on rollers, and so on. Truly the horizon brightens for the desk-bound executive and his staff

FOR FUTURE REFERENCE

SYNTHETIC rubber will have at least three post-war years in which to prove itself for civilian use before imports of natural rubber can be rebuilt. . . And don't forget that political considerations will have definite effects on the whole rubber picture . . Aluminum has a calculating gleam in its eye as it watches development of uses for itself in the electrical industry, where its lightness and relatively high conductivity can be used to good advantage. . Highway engineering in the future will demand trained personnel instead of the part-time working engineers of the past; new highway construction will be on a higher plane. . . Executives in metal-working industries who have not investigated the possibilities of metallizing may be missing a bet. . . Man-made gems—sapphires and rubies especially—that have been developed for industrial uses may adversely affect the gem market in the not far distant future. . . The paint industry is one that will quickly get back into peace-time stride, since reconversion offers practically no problems except in the line of containers. . . . Forward-looking business men are giving serious thought to re-employment of handicapped veterans; more should do the same without waiting for war-end.

Why Tomorrow's Screens Will Say "KEEP OUT!" 4 TIMES AS LONG!



WITH the coming of Victory, rust will no longer limit the life of window screens to a few short years. Corronizing, a new armor against rust, will make possible screens that say "Keep Out" four times as long before rust destroys them!

Already tested and proved, Corronizing awaits only Victory to add to the life and value of hundreds of products. Not only screens, but autos and planes . . . lawn mowers and tractors . . . ash cans, heating equipment, refrigerators and ranges . . . will give up to *four times* as much service for the buyer's money!

The simple, inexpensive Corronizing process is available to all makers of metal products. It was developed through years of research by Standard Steel Spring Company, long makers of special steel products and today a leading producer of armor plate, bombs and other war materials.

Standard Steel Spring Company

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Peacetime producers of automobile bumpers and springs, precision mechanical coil springs, universal joints, floor gratings and stair treads.

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To Executives

in Manufacturing, Engineering and Sales

The Corronizing process is being used on war products and is available right now for essential manufacturing. When Victory is won, Corronizing of your peacetime products will enable you to offer far longer product life —far more for the customer's money. On the retail counter, the "Corronized" label will be a key to easier sales In manufacturing, Corronizing offers unique production advantages Write for details.

50 Years Ago . . .

SCIENTIFIC AMERICAN

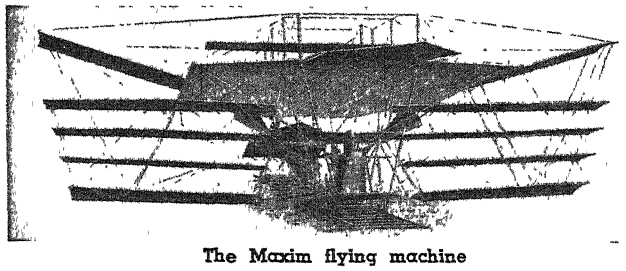
(Condensed from Issues of September, 1894)

ELECTRIC BLANKET — "A new invention, called by its inventor the thermogen, consists of a quilt containing a coil of wire bent in the fashion of a gridiron, inclosed in insulating and non-conducting material, and embedded in cotton wool or other soft substance with a silk or woolen covering The resistance offered by the coil to the flow of an electric current through the wire produces heat . A uniform temperature of about 150° Fah. is thus maintained"

BLAST — "A large and successful blast was made July 29 in the quarries of the American Cement Company at Egypt, near Allentown, Pennsylvania. The blast consisted of 22 charges of dynamite in holes drilled 20 feet deep There was a total of a ton of dynamite It was all set off simultaneously by electricity. . It is calculated that the enormous amount of 12,000 tons of cement rock was dislodged by the blast"

GLASS MARKING — "M Charles Maigot, of the physical laboratory of the University of Geneva . . . has found that by rubbing on glass with an aluminum point we obtain clear metallic lines, which cannot be removed by washing, no matter how often repeated. . . An indispensable condition is that the glass and the aluminum point shall be clean."

FIRST TO FLY — "On Tuesday, July 31, for the first time in the history of the world, a flying machine actually left the ground, fully equipped with engines, boiler, fuel, water, and a crew of three persons Its inventor, Mr. Hiram Maxim, had the proud consciousness of feeling that he had accomplished a feat which scores of able mechanics had stated to be impossible. Unfortunately, he had scarcely time to realize his triumph before fate, which so persistently dogs



The Maxim flying machine

the footsteps of inventors, interposed to dash his hopes. The very precautions which had been adopted to prevent accidents proved fatal to the machine, and in a moment it lay stretched on the ground, like a wounded bird with torn plumage and broken wings. Its very success was the cause of its failure, for not only did it rise, but it tore itself out of the guides placed to limit its flight, and for one short moment it was free. But the wreck of the timber rails became entangled with the sails, and brought it down at once."

PRESERVATIVE PAINTING — "Graphite, mixed with pure boiled linseed oil to which a small percentage of litharge, red lead, manganese, or other metallic salt has been added at the time of boiling to aid in its oxidation, forms a most effective paint for metallic surfaces, as well as for wood and fiber."

METAL VIOLINS — "Aluminum violins were explained by Mr. Alfred Springer. . . He said that sounding boards of aluminum were analogous to those of wood, in that they did not produce secondary tones discordant to the prime tones Among the difficulties encountered was the fact that the plates had to be riveted instead of soldered He overcame uneven thickness of parts of the violin by sheet metal ribbed and arched"

INDIAN IRONWORK — "In the last twenty years, the number of iron foundries and machine shops has greatly increased in India, and the country is less dependent on Europe for general iron work, importations of wrought iron and steel are yearly increasing"

FLY WHEELS — "The enormous amount of energy stored in a revolving fly wheel is strikingly shown when it flies in pieces, as one did in the Manville Mills, at Manville, R I, on the morning of the 18th ultimo In bursting, the wheel destroyed two other fly wheels of the same size, 20 feet in diameter and 25 inch face The break will cause a shut-down of the mills for nearly a month for repairs and the damage amounts to $16,000 Large pulleys and other machinery above the engine room were smashed and twisted into a mass of wreckage Fortunately no one was injured"

ELECTRICITY AFLOAT — "There are some very interesting matters in connection with the new steel passenger steamship Northwest, of the Northern line, especially in reference to the vessel's use of electricity . The vessel is lighted by 1,800 incandescent globes The Northwest's lighting equipment is driven by three direct coupled engines, each dynamo having 600 light capacity The vessel has electric elevators between the freezing rooms in the forehold and the kitchens and cafe"

SHRINK FIT — "A method for instantaneously removing iron parts shrunk on hot, like a crank on a shaft, has been communicated by M Raffard to the Bulletin Technologique of the French Societe des Anciens Eleves des Ecoles Nationales d'Arts et Metiers. . . M. Raffard recommends that molten lead be run round the part to be detached—a method he applied with success in removing a crank that had been shrunk on a shaft 8 inches in diameter"

CAST IRON — "Mr W J Keep . . has for six years been trying to verify the belief that sulphur is in every way injurious to cast iron; and he has made numerous experiments with artificially sulphurized cast iron up to 2 percent of sulphur, both gray and white . . The conclusion finally reached is that the proportion of sulphur retained by gray cast iron cannot materially injure the iron, except by increase in shrinkage. which in the extreme ends seems to be from 0 168 inch to 0 194 inch per foot"

PRUSSIAN SHOES — "On the late visit of Prince Bismarck to the Emperor, the latter called the attention of the ex-Chancellor to the improvement made in the boots of the Prussian infantry. This consisted in the displacement of the old fashioned steel nails by nails from aluminum, which is much lighter and more durable"

SOFT COAL — "Mr C M Higginson, an expert Chicago engineer, in a paper on the abatement of the smoke nuisance, gave the following rules as essential to good combustion: 1 A good draught. 2 Open grate bars 3 Means for supply of air above the fire. 4. Means for mixing the air with the volatile gases 5 Distance in which to complete the combustion of the mixture."

CHROMIUM — "From some new researches of Mr. Henri Moissan upon chromium, it results that, through the use of the intense heat produced by the electric arc, it is possible to prepare fused chromium in very large quantities . The metal obtained under such circumstances takes a beautiful polish. and is not attacked by atmospheric agents It is attacked but slightly by acids and resists aqua regia and alkalies in fusion."

SPEAKING WATCH — "To get up anything new in the way of watches seems difficult. . . Mr. Sivan, a French watchmaker, established at Geneva, has, nevertheless, succeeded in stepping outside of the beaten track in devising a chronometer that speaks the hours, instead of striking them, through an ingenious application of the phonograph."

American fighters make sure our big guns are hitting enemy installations Artillery fire control crew receive directional data from observers and pass it on to gun crews

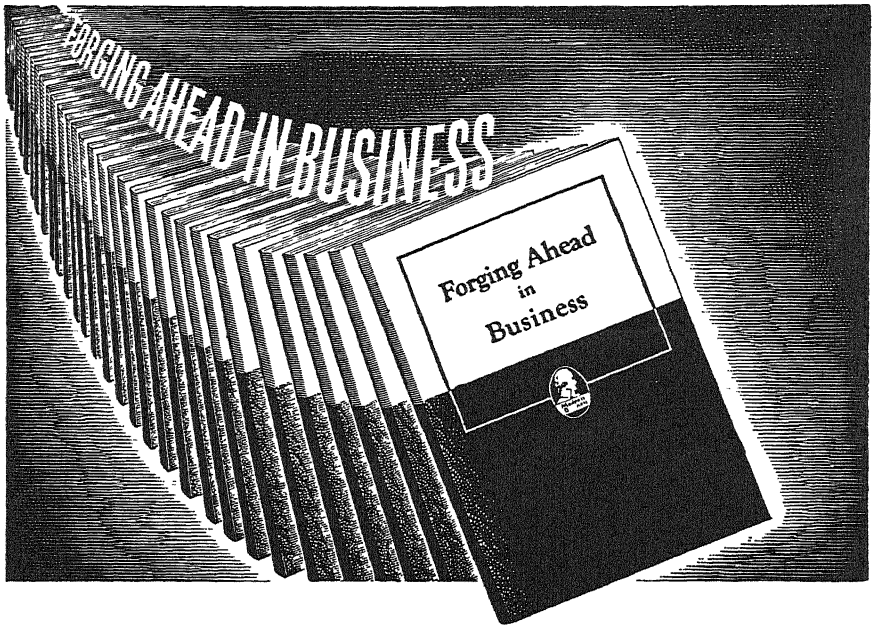
Telephones keep Long Toms on target

War needs the plants and manpower that would normally be making telephone instruments, wires, cables and switchboards for civilian use. That's why there are many people waiting for telephone service.

It will be some time before equipment is available to give service to all who want it. But we shall continue to do everything we can to make that time as short as possible.

BELL TELEPHONE SYSTEM

Please give the service men first call on Long Distance from 7 to 10 each night. That's the best time for most of them to call home.



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Frankly, this booklet has no appeal for the immature mind. It does not interest the man who, for one reason or another, is wholly satisfied to plug along in a mediocre job. But, for the alert, future-minded individual—the man with ambition and "drive"— "Forging Ahead in Business" has a message of distinct importance. If you feel that it is intended for you, don't hesitate to send for a copy today. Simply fill in and mail the coupon below.

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"TELEVISION broadcasting facilities today are within reach of approximately 25,000,000 people, provided receivers were available." *James H Carmine, Vice President, Philco Corporation*

" " "

"IT IS EASY to see how calamitous it would have been a century ago to have been satisfied with conditions as they then existed. We may feel superior to our primitive ancestor who did not know that the mud at his feet would some day be converted to aluminum and permit his descendants to fly, but we cannot be sure that future advances will not make us seem equally backward." Dr George O Curme, Jr, Vice President, Carbide and Carbon Chemicals Corporation

" " "

"PUBLIC EXPENDITURE for new construction after the war should be limited to projects for which there is need in terms of the direct products of construction and not employment." *Wilson Wright, Armstrong Cork Company*

" " "

"FOR THE PERIOD for at least five years after the war the military market will contribute the major proportion of the (aviation) industry business" E. E. Lothrop, Director of Research, Aeronautical Chamber of Commerce.

" " "

"I SUGGEST a fifth freedom—freedom to manage your own affairs unhampered by needless controls, as a necessary adjunct to the Four Freedoms," *Walter S. Tower, President, American Iron and Steel Institute.*

" " "

"WE DON'T WANT to set up a WPA for small businesses. We want companies to give us their plans and policies for reconversion I am 100 percent in favor of helping them, but not running them." Chairman Donald M Nelson of the War Production Board

" " "

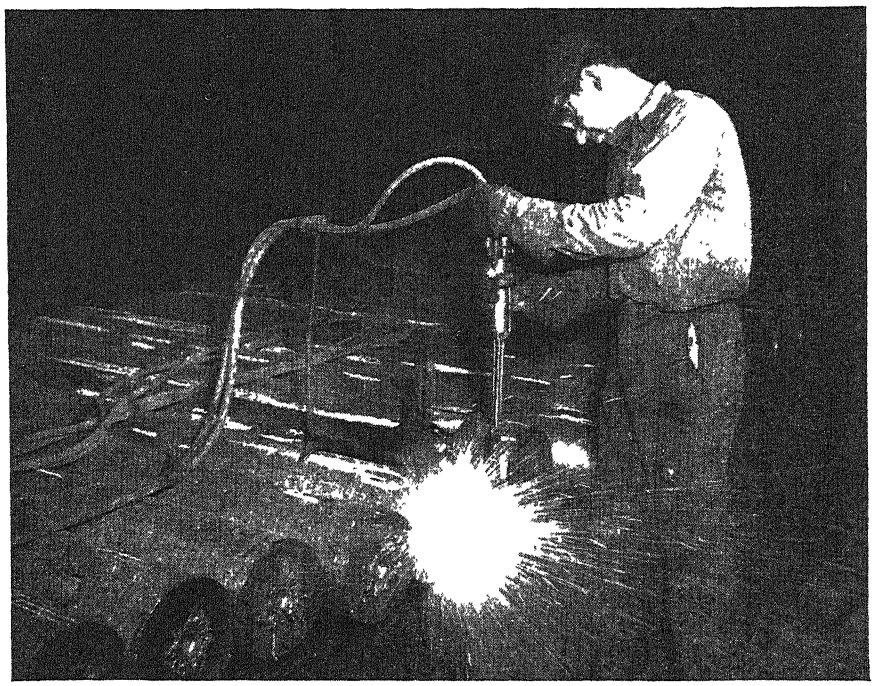
"A VIRTUAL VACUUM of all kinds of electrical appliances has developed, and it will take months to stock distributors and dealers once production has been resumed, to say nothing of meeting the urgent demands of the public" *James H. Carmine, Vice President, Philco Corporation.*

" " "

"THERE ARE MANY startling developments of the war that will be adapted to consumer purposes in the post-war period. However, in the early stages before tools can be built, demand established, and cost gotten down on these new products, the primary—if not the almost entire—dependence for commercial activity and employment opportunities must be on the old pre-war products or on minor variations of them" L. R. Boulware, Operations Vice Chairman, WPB.

METALS IN INDUSTRY

Conducted by FRED P. PETERS



Courtesy Linde Air Products Company

Billets for seamless steel tubing, after being flame cut to correct length and lined up side by side, are quickly centered by an oxy-acetylene cutting blowpipe

Flame Filled Future

Oxy-Acetylene Flames, Once Thought to Have Extremely Limited Uses, are Branching Out as Versatile Tools in the Metal-Working Industry. They are Being Used to Cut Threads, to Work the Hardest Steels, to Correct Warpage, for Surface Hardening, and in a Number of Other Applications

By DANIEL MINTURN

WAY BACK in the gay nineties when more than 90 percent of modern metals fabricating methods had yet to be born, the oxy-acetylene blowpipe was a familiar sight in every railroad repair shop, manufacturing plant, and steel fabricating yard. Strange to relate, during the last 40 years thousands of methods engineers have written off the blowpipe as a tool which had long since reached the narrow horizons of its field of usefulness. Yet during this war the blowpipe has accomplished the impossible so many times that nobody any longer tries to guess where its horizons may be. The tool whose abilities everybody knew, has become the tool whose future nobody guesses.

The trouble is, nobody can tell which uses of oxy-acetylene flame are new developments of this war, and which are really mere extensions of old techniques.

Cutting cast iron is an example Any well thumbed old textbook will tell you that the oxy-acetylene flame cannot cut gray iron castings successfully—the graphite in the cast iron is refractory enough toward heat so that it shields the iron areas against the temperatures at which they will burn, and some of the oxides melt at higher temperatures than the iron itself. Nevertheless, cast iron has been cut successfully for the past several years. The amount of preheating is greater than for low carbon steel (low carbon steel is the easiest ferrous metal to cut), the flame is given an excess of acetylene which helps to keep up the preheating, the cutting temperature is higher, but, most of all, the torch is moved so that it takes a series of moon-shaped bites, keeping hot slag and molten metal washing down through the cut and adding to the preheating. Used mostly to remove damaged parts of castings or to cut vees in broken castings preparatory to welding in the pre-war days, the blowpipe now is one of the commonest foundry tools for removing risers and other extraneous metal from castings.

Another of the "impossibles" was torch cutting of some of the stainless steels. Here the flow-of-slag method has been borrowed from cast iron cutting technique. Each piece of stainless is sandwiched between two plates of readily-cut low carbon-steel. The cut starts in the low carbon steel and washes its way down through the stainless. The sandwich can be a double decker, or triple —alternate layers of low carbon and stainless can be built up for the stack cutting method.

One of the oddest things in the oxy-acetylene picture is the number of "insiders" who don't realize how the blowpipe art has cut through its old bonds, and therefore don't see what is going on around them.

FLAME-CUT THREADS—The editor of a prominent technical journal, for example, overheard two engineers talking about cutting threads with flame. He approached to talk to them, only to have them escape in the crowd. The

publicity man for an equipment maker likewise had never heard of this. But thread cutting for lead screws has been done with flames since 1932 It originally developed from deseaming—the removal of flaws or seams from the surfaces of steel. Often a seam or fault would be caused to go spirally around the surface of a round bar, the accuracy of pitch of the spiral being produced by the evenness of the speed with which the bar passed through the rollers in the steel mill In flame-gouging this seam, so that a flawless bar might be finished, the oxy-acetylene torch naturally was made to follow the accurate pitch of the seam itself, and therefore to cut a groove which looked like a coarse lead screw

Accordingly when lead screws were wanted for special conditions, and did not need to be too accurate, on more than one occasion the flame was used to cut them. Accuracy could be gained by making several passes with different blowpipe heads to get different shapes of flame. Often the lead screw was cut and hardened in one operation

How accurate the cutting of threads with flame has become, and how fine are the finest threads being cut, is one of those secrets which will come out after the war But the accuracy of flame cutting in general is far higher than most engineers envision

In cutting off low carbon steel, for example, precision flame cutting equipment can maintain the following tolerances in day-by-day production:

Stock to	1″	thick,	plus or	minus		0.003″
”	” 2″	”	”	”	”	0 010″
”	” 4″	”	”	”	”	0.0175″
”	” 6″	”	”	”	”	0 0312″

Highly skilled operators, who know how to keep their machines in adjustment, can do much better than this. These figures are safe ones—safe for machine makers to cite when they are not too sure of the skill of the operators who will use their machines.

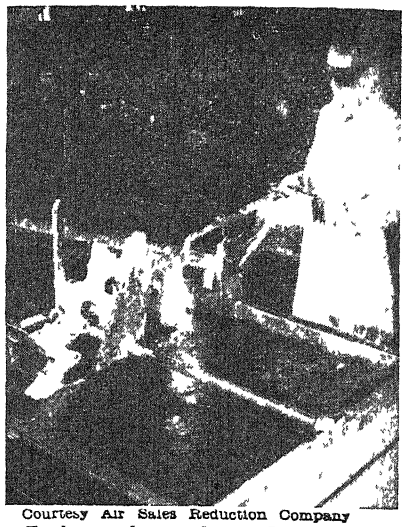
As in all metal-cutting operations, the higher the accuracy the slower the work Nevertheless, in making cuts which ordinarily would be made on milling machines or planers, a single flame-cutting head can remove from 500 to 1800 pounds of soft carbon steel an hour. How this compares with the best that machine tools using cemented carbine tools can do today is not known; but in pre-war practice the flame cutting was 200 percent to 300 percent or more faster than the best of other cutting tools, provided the cuts to be made were suitable for flame methods

On harder steels the differences were even greater Comparative figures were being compiled when Pearl Harbor interrupted the research But, for quite a few steel types, the harder the steel the greater the speed differential in favor of flame machining.

All flame-machining men like to make it clear that flames are not likely to drive other cutting and fabricating methods out of business. Flames are doing remarkable work in their own fields, but they cannot do everything They can, for example, rough plane a steel plate, preparatory to finish grinding, if a further smoothness is needed, but they cannot finish plane it (Or, at least, not yet.)

Flame heads are like other tools. They can be varied to change the sizes, shapes, directions, chemical effects, and to some degree the temperatures of the flames They can be equipped with spraying or quenching devices which keep down the temperatures of the work areas. And they can be ganged

One example of ganging is the rip-trim cutting of plate edges preparatory to welding For this, three flame heads are ganged on a planer. By being directed at suitable angles, two of these heads bevel off the top and bottom corners of the plate edge, while the third cuts off the sharp apex where these two cuts meet at the middle of the plate edge, this cut leaving a "nose." As a result, when two edges of these plates



Courtesy Air Sales Reduction Company

Tank sprocket teeth are flame hardened, then water quenched, to impart hardness and wear resistance to withstand grinding against the treads

are abutted for welding, two small vees are provided instead of one large one to be filled up with the welding rod, and the weld is performed with half the consumption of rod that was needed for the old-fashioned single deep vee

Another example is in contour cutting. As originally done, a single blowpipe followed the entire contour of the piece to be cut from flat or other stock Now two or more blowpipes attack simultaneously at various parts of the contour, getting the work done much faster In some cases several contours are cut simultaneously from the same piece, as when an outside or peripheral contour, an inside or "hole" contour, and several piercings from the remaining or "rim" stock, are to be produced Machines which perform several operations at one time usually have full electrical controls operated from highly complex panels. The limits to the future of their development are nowhere in sight

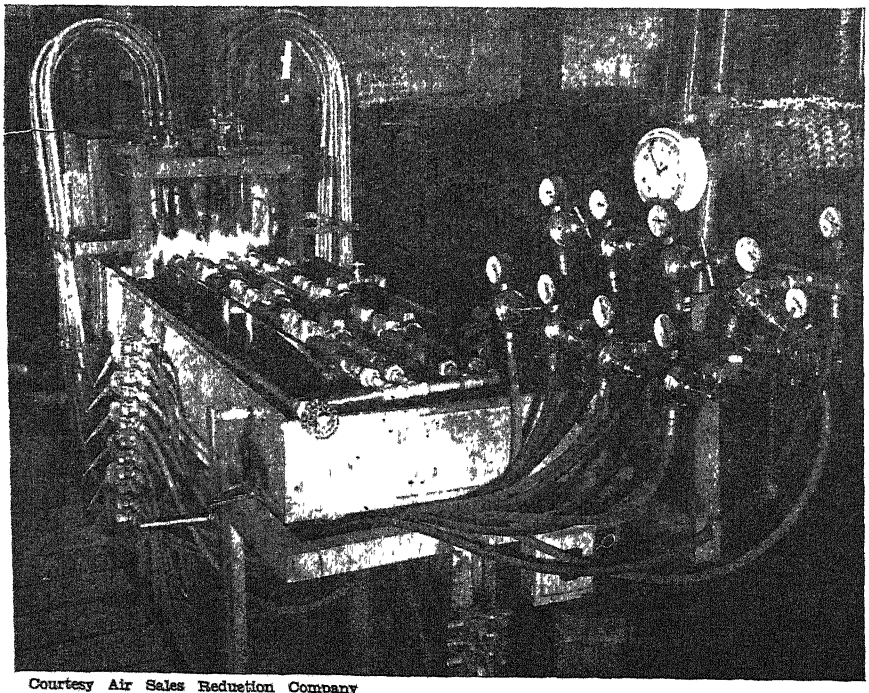
MANY CUT AT ONCE—Parts to be cut on contours are quite commonly stacked and thus many are cut at one time The contour may be sketched right on the stack, and followed by hand However, for high production a template or other permanent guide is provided, and the machine follows this, the flame head being guided by some form of pantograph mechanism

Often the primary guide is a simple steel pointer which is manipulated by hand to follow a line on a drawing. Other models use power to run the guide around a template, or to cause it to follow a track or to cling to a magnetized path.

One of the latest devices employs a photoelectric cell which, by interpreting variations in light, will cause the guide to follow a drawn line

The details of some of the best of these controls are not being released at the present moment. When military secrecy is abolished, the art of flame cutting of contours will be found far advanced from its prewar days.

Flame hardening of surfaces is another old practice which is becoming



Courtesy Air Sales Reduction Company

A conveyorized eight-torch flame hardening machine at work on tank grousers

brand new. It is safe to say that our military tank production program—the first in the war to cross its peaks and suffer cutbacks—never could have been carried out at all if flame cutting and hardening techniques had not been available.

Size is no deterrent to the flame hardening of parts. Small parts may be hardened, thin sections hardened without warpage or destructive strains, or small sections of large parts hardened locally while leaving the remainders soft.

The hardening process may be that of heating the steel through its critical range and then quenching in air, water, or oil, or may include a degree of carburizing.

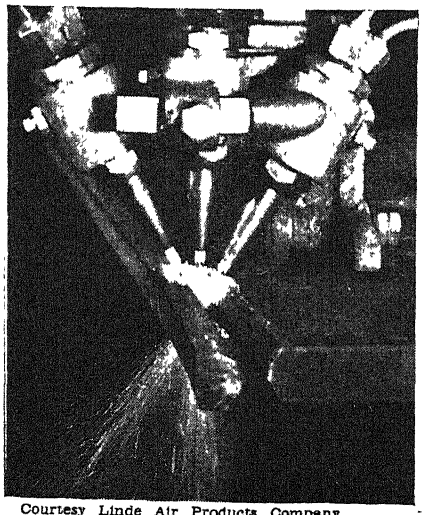
NEW ABILITIES DISCOVERED—All this was known before the war But the war brought out the real abilities of flame hardening in short order.

Railroad switch frogs, for example, always had been made of manganese steel. Manganese gave the steel toughness with which to take the beatings and the shocks from fast rolling, heavily loaded wheels. But when shortage of manganese came to the steel mills, flame-hardened carbon steel frogs were tried. So well have these "emergency" frogs stood up, that some railroad men believe manganese types may never come back.

In the meantime flame hardening had to be brought to the nicest degrees of control, so that duplicate results would be obtained. Modern processes control the temperature, the volume of heat applied (B.t.u.), the pressure, depth of heating, and time of application. Going on from there, the temperature of the quench and the draw (heating, quenching, and drawing may be performed in one operation) were controlled.

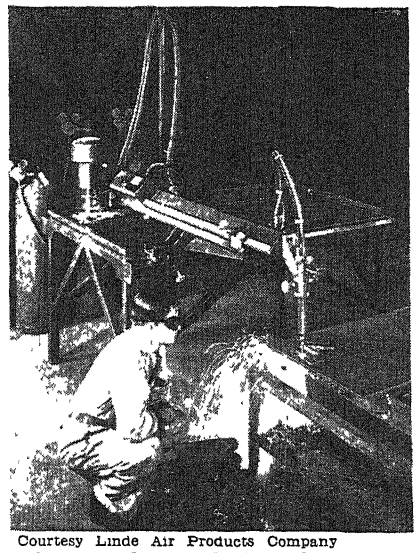
The hardening process was brought to the work instead of the work of the furnace Ways and bearing surfaces were hardened on machine tools, followed by quenching either with water, with water and compressed air to form a mist, or with compressed air alone.

Control goes to such extents as to harden the odd teeth—numbers 1, 3, 5, and so on—on a gear in succession, then the even ones, to avoid over-hardening at the root of any tooth. Gears and other parts may be stacked for hardening, a row of teeeth on several gears in a stack being hardened, then the following row In many cases water sprays are used to keep cool the parts that are not to be hardened.



Courtesy Linde Air Products Company

Rip-trim cutting of plate edges prior to welding them is done with this unit with three ganged flame heads



Courtesy Linde Air Products Company

Pantograph controlled machines of this type are widely used for automatic flame cutting of steel plate

Thin parts which had warped while being hardened in furnaces—worms, shafts, and shear blades, for example—formerly had to be discarded. Now a touch of flame is given to the high spot, the top of the bend. Often the flame is applied for only one second to a spot. Nevertheless the heated metal, trying to expand and being held by the metal around it, will upset and shrink when it cools, pulling the piece into straight line. This takes a skilled operator, but in the case of some welding operations the straightening becomes a repetitive task and a less skilled operator can perform it.

Long, flat plates or other pieces will warp as the result of welding, or from concussion or other violence. They can be straightened in this way. Borrowing a page from the book of the flame hardener, automatic quenching sprays are being applied around flame heads to keep the temperature of the heated metal down to 600 degrees, Fahrenheit, or so; this permits the flame straightening of galvanized sheets since the zinc does not melt or give off dangerous fumes until it is at 750 degrees, Fahrenheit.

The shrinking and upsetting action from spot heating will raise "welts" on steel surfaces. Produced in carefully controlled bands or areas, these can be used to reduce the bores—or the contact areas of bores—of sleeves which have been made oversize, or to increase the effective diameters of shafts which must fit such bores.

Flame brushes are used to remove scale, rust, and moisture from steel surfaces before painting. The result of this is to present a clean, dry, warm surface to which priming coats bond with unusual smoothness and tightness; the paint dries from the inside out instead of from the outside in.

As results of these techniques, oxy-acetylene blowpipes are found where steel is cut, welded, soldered, brazed, hardened, repaired, or painted. Plant after plant is piping oxygen to large departments from central distributing points, as ordinarily as a management runs water pipes or electric wires.

What the industrial future of oxy-acetylene will be—where it will meet surprise displacements by other war-developed processes and where it will surprise its own practitioners by the things engineers have learned to do with it—nobody knows right now. But one thing is sure: Although it is one of the oldest techniques, oxy-acetylene is to have one of the newest industrial beginnings.

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NEW LEAD COATINGS

Give Corrosion Resistance To Sheet Steel

THE CORROSION resistance of lead and its alloys has in the past been utilized chiefly in products made from lead sheet, pipe, and so on. In recent months, however, new lead alloys and fluxes have been developed that permit the rapid, uniform, and highly effective coating of steel with lead alloys; the resulting products possess the strength and light weight of steel plus the corrosion resistance of the lead.

The alloys, developed by The National Lead Company, contain small amounts of tin and have excellent working properties, including improvement in their hardness on aging. They can be handled in present hot-dipping equipment of the usual type and are being applied with economy of money and materials and excellent service results to such diverse items as gasoline tanks, radiators, oil containers, boat brackets, air-conditioning ducts, convection heater coils, radio housings, metal fencing, farm equipment, and so on

POWDER METALLURGY DEVELOPMENTS

Involve Copper-Coated Steel and Aluminum Bearings

TWO RECENT developments in the application of metal powders in the fabrication of mechanical parts are significant from the standpoint of post-war metalworking.

One is the use by the Navy's Metal Process Section (under R. G. Olson), of a copper-coated steel powder and a braze-sintering process in making gears and other parts that must be shock resistant, highly precise, and made in large quantities. The copper-coated powder is pressed to shape in the usual powder metallurgy presses but, instead of "sintering" the parts in the usual way, the Navy heats the briquettes to a copper-brazing temperature (about 2000, Fahrenheit) in a hydrogen atmosphere; the copper melts and forms a cementing

(*Please turn to page* 134)

Electronic Counting

A Newly Developed All-Electronic Counter Decade Now Makes Possible Accurate Counting at Rates up to a Million Objects per Second, Surpassing Mechanical and Electromagnetic Counters in Accuracy and Versatility. It Can be Applied to a Wide Range of Industrial Counting Jobs

ANY moving objects capable of interrupting a light beam or of producing an electrical pulse can be counted electronically. If the objects are on a moving conveyor belt, the beam is simply directed across the top of the belt at the proper level for interception. It is aimed at a phototube which is connected through an amplifier to an electromagnetic counter. If the objects are cosmic particles bombarding the earth, electrical pulses are produced by catching these particles in a metal can called a Geiger counter, and the pulses are fed into an all-electronic counter that ticks off the count by means of blinking lamps.

Electronic counting is most appreciated in connection with objects that for some reason must not or cannot be touched during the counting process. Examples are counting of freshly painted objects, fragile glass objects like radio tubes, sterile articles, delicate sheets of paper moving at high speed through printing or folding machines, unwrapped foods and meats, people or animals passing a given point, flashes of light such as those due to flashover on generators, and irregular-shaped or light-weight objects that could not readily be positioned to actuate mechanical counters reliably.

One industrial application is counting the actual output of a punch press where feeding conditions are such that the press may now and then operate without material, making a count of press operations inaccurate as a production figure.

Whether electronic counters are preferable to simple mechanically actuated counters or to lever-operated switches serving electromagnetic counters depends upon production conditions when it comes to products outside the untouchable category. Consideration of electronic equipment for any counting job is certainly justified, however, in view of the wide variety of existing commercially successful applications. These include counting of automobile running boards, connecting rods, tire casings, refrigerator parts, steel ingots, billets, bars and sheets (both hot and cold), mica sheets, logs, bottles, beer cases, sacks of sugar and bags of candy, tea, and cocoanuts, to mention just a few.

Electronic counting removes the accurate-positioning requirement of other methods because the object can interrupt any part of the light beam. The cost of an installation in many instances is under a hundred dollars since packaged electronic units made by mass-production methods are suitable for most jobs. Maintenance is no problem because there are only a few radio parts in the equipment in addition to the automobile-type lamp in the light source, the phototube, and a few radio-type vacuum tubes.

At relatively slow counting rates, such as are encountered in this Westinghouse conveyor installation, a light source and phototube unit mounted on opposite sides of the conveyor provide an accurate count of cartons or other objects moving past, regardless of quite wide variations in their sizes, shapes, or relative positions

SIMPLICITY PLUS— Electronic counters of various types have been in use for many years, principally for such research purposes as counting cosmic rays, but this essentially experimental equipment has generally been both bulky and costly. A simple electronic counter, developed recently by John T. Potter of Potter Instrument Company, shows every promise of meeting industrial demands for a "streamlined" model that is economical to manufacture and dependable under a wide variety of conditions It should find definite applications in fields where the characteristics of electromagnetic or mechanical counters place operating speed limits on associated machinery or apparatus.

A suitable number of the basic counter decade units (one for each digit in the maximum quantity to be counted) can be readily connected to appropriate input circuit accessories for any particular industrial application.

The counter decade uses a minimum number of parts and tubes to represent the numbers from 0 through 9. Various combinations of four numbers may be used to constitute a full decade, such as 1-2-2-5, 1-2-3-4, 1-2-4-8. The last combination, 1-2-4-8, is a binary progression that may represent the numbers 0 to 16 if properly used.

The binary system is well adapted to electronic counting. A series of trigger circuits may be connected in

such a manner that two pulses from one circuit may cause one operation of the succeeeding circuit. The binary system of notation is difficult to interpret, however, since all of us have been educated to interpret numbers by the decimal system For this reason it is necessary to introduce a method of stopping the binary counting progression at the count of ten and resetting the electronic counter to zero. This is accomplished easily and automatically by two feedback capacitors in the new counter.

The counter decade comprises four stages, each employing an ordinary dual-triode vacuum tube (such as a 6SN7, 6N7, 6J6, and so on) arranged in a trigger circuit in conjunction with an indicating neon lamp. The basic functioning of all stages is alike, and is dependent upon shifting of operating potentials back and forth between two sets of values each time a signal pulse enters a stage.

Each stage, then, has a neon lamp and two tube sections which, for convenience, can be designated as the L section and R section. Only one tube can conduct current at a time, and the neon lamp can glow red only when the L section conducts. Each electrical pulse fed into the stage causes a switchover from one tube section to the other. Thus, if the R section is initially conducting and the neon lamp is out, the first arriving pulse will block the R section and make the L section conducting, so the neon lamp comes on The next pulse will restore original conditions and put out the lamp, with this process repeating itself for succeeding pulses.

In a complete counter decade for providing a count of 10, four stages are used end to end. Each time the neon lamp goes out in a stage (due to switchover from L section R section), the stage sends a pulse on to the next stage The resulting blinking of lamps during a long series of incoming pulses looks pretty confusing, since it takes two blinks of one lamp to make one blink of the succeeding lamp, but the beauty and efficiency of the system becomes readily apparent if the lamps in the four stages are numbered 1, 2, 4, and 8 respectively in the binary system. As will be seen later, the number assigned to each stage is equal to the number of pulses required at the input of the decade to make the neon lamp in the stage come on the first time.

HOW COUNT IS MADE—The manner in which four neon lamps can give a count up to 10 is shown in the drawing. For zero all lamps are out, as indicated by dark circles, and hence the R sections are conducting in all four stages. The first pulse turns on lamp 1 and we count one, as indicated in the second horizontal row. The second pulse puts out lamp 1 and turns on lamp 2 so we count 2. The third pulse turns on lamp 1 but does not affect lamp 2 (remember, only when lamp 1 goes out does stage 1 send a pulse to stage 2); two lamps are glowing, so we add their values to get a count of 3. The next pulse puts out lamp 1, sending a pulse to stage 2 to put out lamp 2, and this stage in turn sends a pulse to the next stage to turn on lamp 4 and give a count of 4. The process continues in the same fascinating manner through a count of 9.

For its tenth operation, the decade must transmit a negative pulse to the succeeding decade and must reset to its original zero condition as required by the decimal system. This means that the tenth pulse must put out all lamps. The count of 10 in the binary system calls for lamps 8 and 2 being on, hence lamp 1 (on for the 9 count) will go out automatically. Forced resetting therefore means putting out lamp 8 and preventing lamp 2 from coming on. This is ingeniously accomplished with two capacitors, as follows:

After the ninth pulse, the left-hand sections are conducting in both stage 1 and stage 8. When stage 1 is reversed by the 10th pulse, a negative pulse obtained in this stage is fed through a capacitor to stage 8, putting out lamp 8

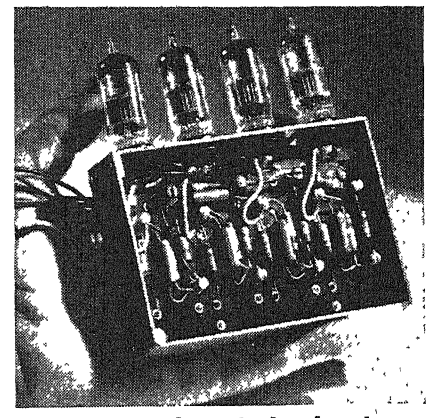
In an essentially similar manner, a positive pulse obtained from stage 8 during the forced switchover of this stage is fed through another capacitor to stage 2, where it completely overwhelms the negative pulse fed into this stage from stage 1 Since the lamp for stage 2 was out after the ninth impulse, it therefore stays out. All lamps are thus out for the count of ten (or zero), with one pulse being fed to the next decade (where the first lamp would represent 10, and the others 20, 40, and 80, respectively).

Pulse No.	Stage 1	Stage 2	Stage 4	Stage 8	Count
0	R	R	R	R	= 0
1	L	R	R	R	= 1
2	R	L	R	R	= 2
3	L	L	R	R	2+1 = 3
4	R	R	L	R	= 4
5	L	R	L	R	4+1 = 5
6	R	L	L	R	4+2 = 6
7	L	L	L	R	4+2+1 = 7
8	R	R	R	L	= 8
9	L	R	R	L	8+1 = 9
10	R	R	R	R	Forced reset to 0

How neon lamps on counter panel indicate count. See text description.

An unusual feature of this type of counter decade is the ability to operate at pulse rates ranging all the way from above 100,000 times per second down to as low a rate as desired, with no substantial changes in circuit constants. It is only necessary to provide a negative pulse at the input that is approximately the correct strength and shape. When sine-wave input exists, as from an oscillator that is started and stopped at the beginning and end respectively of the interval to be measured, a single multivibrator stage is generally inserted between the oscillator and the decade input for pulse-shaping purposes.

MANUAL RESET—The counter decade may be reset to zero manually by momentarily pressing a push-button switch, then selected counters may be turned on before a count. If, for example, lamps 2 and 1, or a count of three, are turned on manually, then the output will operate when seven pulses have passed through the counter. In this manner, the future performance of a counter may be rendered predetermined.



A complete electronic decade using four miniature tubes. The neon indicating lamps are remotely mounted

In the case of welding timing, the counter may be operated from the 60-cycle power frequency, and after a predetermined reset will count the exact number of cycles going into a weld. In the same field, the counter may be used as a cycle counter to check present timing equipment.

One of the widest present uses of electronic counters is in the field of interval timing. In this application, a crystal-controlled oscillator frequency is fed into the counter by an electronic switch or gate operated by initiating and terminating pulses from the time interval. With five decades and a 100,000-cycle crystal, intervals up to one second can be read with an accuracy of 0.01 percent for a full-scale reading.

Many variations of this type of counter may be useful. For example, an accumulated count may be used with fewer decades to indicate whether a watch is fast or slow, from the 5-cycle on and off beats of a watch. A predetermined number of beats can be used to switch the counter on and off, giving an accumulated reading that would average out any errors caused by irregularities of the watch rate.

Camera shutters or exposure timers can readily be tested by using a counter to indicate the accuracy of timing of the spring movement.

The counter used as a chronograph can be applied in practically all cases that at present use some graphic recorder for recording a time interval against a time base, with the advantage that the time interval will be directly and immediately indicated on the panel of the counters.

Most counters used as scaling circuits in radiation counters up to the present have not had a resolution time comparable to the resolution time of the counter tube. The electronic counter just described has a resolution of 0.00001 second and can readily be made to have considerably higher resolution.

a mechanical counter decade. Substitution of an electronic decade should give much greater speed and may result in a less expensive method of adding, subtracting, dividing, and multiplying, especially in business uses.

The electronic counter offers a method of increasing the rate of circuit selection, now generally done by stepping relays as in dial-telephone operation. A series of rapid pulses may be transmitted over a line for almost instantaneous selection of a desired circuit.

Electronic counters will provide an accurate count when objects are moving through the light beam of a phototube system at rates higher than can be handled by a mechanical counter. Electronic counters can handle any counting rates encountered in industry, even up to a million objects per second They can increase the operating speed of such equipment as card-counting sorters, now limited by the speed of mechanical counters.

Many industries use the technique of ratio-weighing. A very fast counter used with a sorter and photoelectric pickup would give greater accuracy, especially in instances where a variation occurs in the density of the material in the article being sorted.

The electronic counter thus promises to become an important tool for use in many fields. Undoubtedly its development will stimulate thinking directed to a multitude of additional uses

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ELECTRONIC THERMOMETER

Utilizes Resistance Coefficient of Liquid

A NEW temperature measurement and control system utilizes an electronic arrangement to provide a much lower heat lag than most conventional types of temperature controls used on heating systems. Another advantage is that the system permits indications of temperature to be made at distances of several hundred feet from the controlled point.

Operation of the instrument depends on the extremely high temperature coefficient of resistance of some organic liquids. A small glass bulb containing two thin wire electrodes is filled with the thermometric liquid and an alternating voltage applied to the electrodes. Changes in temperature cause the resistance between the two electrodes to change and thereby change the voltage bulb is connected.

An electronic amplifier and discriminator receives the alternating voltage and produces a direct current flow to actuate a sensitive relay for control purposes or an indicating meter for observation. The sensitivity of the system can be adjusted for a ± 0.01 degree, Fahrenheit, range of control. The instrument was developed by Kollsman Instrument Division of Square D Company.

Typical thermometer bulb designs

RADAR FOR TRAINS

May Develop Many Safety Applications

A PROGRAM of study and experimentation in the use of radar and other electronic devices for train communication and control has been inaugurated on the Chicago, Rock Island, and Pacific Railway. The plan is to develop a radio communications system in the microwave region for use between the front and rear end of trains, in yards between yard offices and switching crews, and ultimately between dispatchers and crews of trains enroute.

Experimentation on the Rock Island in the use of radar, particularly in safety applications, may also have far reaching practical applications in the safe and efficient operation of trains

CAB ROUTING

Would be Accomplished by Radio Under New Plan

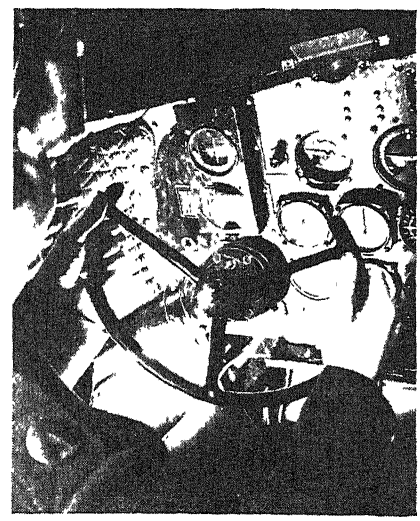
IF ALL the companies that plan to utilize radio equipment after the war are allowed to do so by the Federal Communications Commission, the day of personal two-way radio telephones may soon arrive. Already, railroads and utility companies are keeping in touch with their rolling stock by means of two-way radios and plans are being worked out for taxicabs in Cleveland to use such apparatus.

Cab Research Bureau, Inc., representing the taxi industry, and the Electronic Department of General Electric Company, are working on plans that would make it possible to establish contact with any cab at any place in the city, reduce cruising mileage, and eliminate unattended call boxes connected to telephone lines. If approval can be obtained from the Federal Communications Commission, this will be the first two-way taxicab radio system in the United States

ELECTRONICS GUIDES PLANES

Crossed Pointers are Actuated by Radio Signals

BLIND landings by planes within 50 feet of a pre-selected spot on runways are made possible by an instrument now being built into combat planes and training planes. The instrument, shown in the photographs, is the indicator of an electronic system that is the result of seven years of continuous research and development by Westinghouse Electric and Manufacturing Company and the



Above: Checking blind-landing instruments. The third unit from left shows correct position of pointers when landing. Below: The blind-landing instrument is on the panel just above the pilot's control post

Washington Institute of Technology, which worked with the United States Navy to originate a simplified device for taking the guesswork out of blind landings.

In use, the pilot watches two crossed pointers and two signal lamps on the instrument. Positioning of the pointers is accomplished by two radio receivers which pick up directional radio beams transmitted by the ground equipment One receiver responds to the localizer, or on-course beam, and moves the vertical pointer on the instrument dial. The second receiver responds to altitude signals and actuates the horizontal pointer.

The ground radio equipment consists of four radio transmitters and two antenna systems located near the airport. These produce beams which first indicate the pilot's approach to the field and then mark the field's boundary; establish the invisible glide path which leads to the runway; and signal directions for keeping the glide to the field neither too shallow nor too steep.

The electronic landing system is in daily service at several commercial airports as well as on Army and Navy flying fields.

Airports for America

Civil Aviation Should Advance Rapidly After the War. Some Six Thousand Airports will be Needed and the Initiative, also Most of the Development, Should be Local Whether for Large Cities, Medium Cities, or Villages. How May the Interested Reader Go About that Initiative for his City?

THE WAR has led to the construction of many large flying fields well adapted to military needs, but has not produced a coordinated system of airports adequate for the real needs of the United States. If civil aviation is to advance rapidly in the post-war period, there must be a national airport policy, bold investment of funds, full co-operation between Federal Government, states, and municipalities, and, what is perhaps even more important, the help of interested citizens in thousands of communities.

Immense airports will be needed, with long runways for the huge passenger and cargo airplanes now being designed or already in operation—runways 7000 feet in length. Also needed will be a great number of smaller fields for short-haul or feeder line transportation. And, finally, air traffic will require many small fields or flight strips if the private owner is to make use of the efficient and safe, modern planes that will soon be at his disposal.

Charles I. Stanton, Civil Aeronautics Administrator, summarizes these needs There are now 3000 civil airports, of which some 900 are suited for heavy operation There will be need for 600 extra fields immediately after the war, and soon thereafter at least 3000 extra fields in all, which will bring the total number of fields to 6000. Mr. Stanton made this estimate partly on the basis of there being 6670 communities having a population of 1000 or more in the United States.

William A. M. Burden, Assistant Secretary of Commerce, has estimated the investment needed at $800,000,000, or about double the present investment. Yet this will be only one third of the annual expenditure of $2,250,000,000 for roads and highways incurred by our governmental authorities. Mr. Stanton has submitted a financing program to Congress whereby Federal funds will be apportioned on the basis of the area of the state, the size of population, the number of aircraft in service, and the number of airports within a given region. The Civil Aeronautics Authority has also established an Urban Planning Section to work with local authorities in surveying and planning. It is not sufficient, however, that the CAA put forth its best efforts. Local communities themselves, not only officials but business men, merchants, public spirited citizens generally, must help in building up our national airport system.

AIR TRAFFIC GROWTH—If any city in the United States is entitled to a series of airports, it is New York. About 67 percent of all Americans who go abroad live within the northeastern regions of the United States. When Fiorello H. La Guardia started to build the field later named for him, he was criticized as a visionary, yet La Guardia Field reached the saturation point even prior to the war, and during the war it has handled in one month 500 large planes. Some 4000 passengers and 2,500,000 pounds of cargo left in one month for the United Kingdom and North Africa. Prior to the war, La Guardia Field handled a million passengers a year.

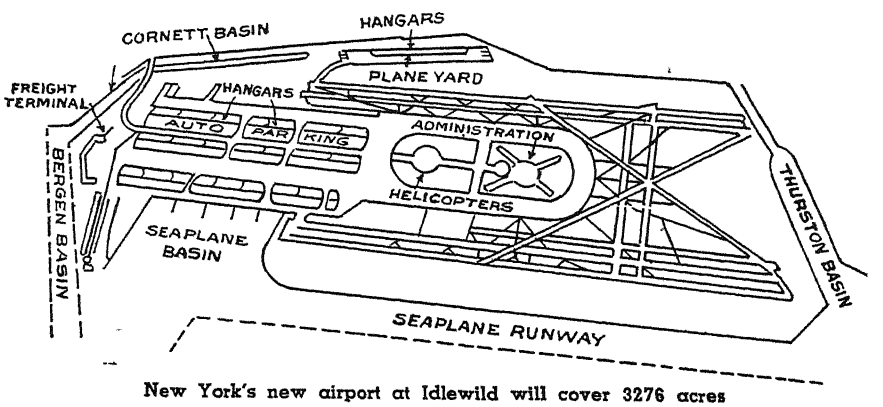
New York's new field, Idlewild, which also will be in that part of Long Island that lies within the limits of New York City, is therefore being planned for use ten years hence, but in all probability it will be congested three years after it is put into service.

The statistics of the new terminal, as given to us by Jay Downer, its engineer-designer, are imposing. Area will be 3276 acres (at first the figure was set at 500 acres, but it was soon agreed that this figure was ridiculous). Dredging and filling requires 39,000,000 cubic yards. Length of drains, 28½ miles. Length of runways, 14 4 miles. Concrete in runways and taxiways, 2,050,000 square yards, concrete in loading aprons, 1,200,000 square yards—both 12 inches thick. Estimated cost, $45,000,000 for the field and $15,000,000 for the buildings, including one hangar. This estimate of cost is, of course, too low. It is much more likely that the cost will run to $100,000,000.

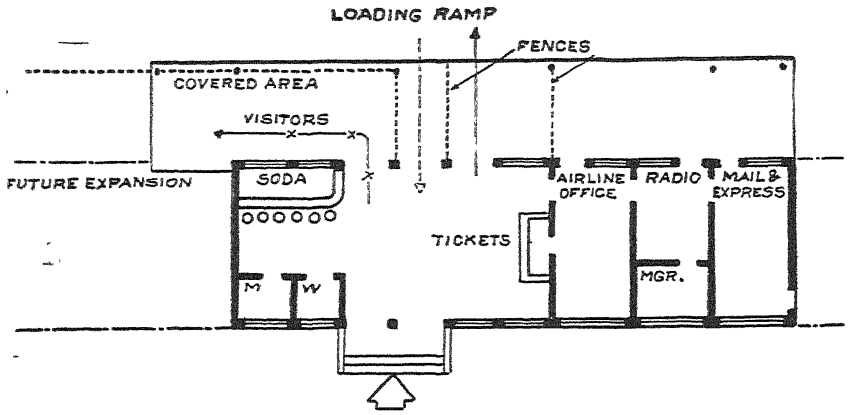
In spite of the huge task, Commissioner McKenzie hopes to have the airport in operation by the end of 1944. Hundreds of tons of fill are being dredged rapidly from Jamaica Bay. The airport will have both long land runways and a vast seaplane runway in the well protected waters of Jamaica Bay. It will be provided with a seaplane basin, parking space for helicopters, a huge auto parking space, runways ten thousand feet long, plane yards, repair hangars, 40 hangars to be leased to the airlines, the most complete administration and public facilities, and bus services for employees and workmen within the airport itself. With rent from the hangars and concessions, and the daily sale of 2,000,000 gallons of gasoline, the municipal authorities hope that the undertaking will be self-supporting.

FIELDS FOR PRIVATE FLYING—Idlewild gives a picture of the airport terminal in its most ambitious form. For contrast, and because private flying is just as important in its way as scheduled airline operation, a consideration of the small field for the private owner is in order. Here we are indebted to an excellent booklet written by W. T. Piper of Piper Aircraft, entitled "What Your Town Needs for the Coming Air Age."

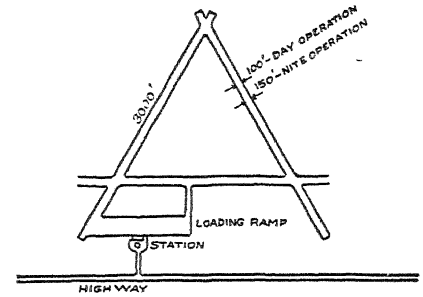
From his writings, addressed to the Mayor of any small city, comes this: "Man of little income, everywhere, is going to fly. He will use the large city airport if he hasn't a smaller one in his own locality. To thin out the congestion that would result in excessive use of the large airports by private planes, landing



New York's new airport at Idlewild will cover 3276 acres



Above: Station plan for a Class 2 airport Simplicity plus utility are important factors in such airports on feeder lines. Right: Runway pattern for a Class 2 airport



strips and small airports are needed in great numbers in the towns and even in the vicinity of the larger fields."

Separate fields for private planes are all the more necessary because these land at lower speeds than do the large planes, and therefore intensify traffic problems. Mr Piper continues· "Every town, village, hamlet, and cross road should establish its landing area. A national system of small airports and landing strips must be developed to take care of private flying and short-haul air transportation. Be sure your community is included."

Certainly many benefits are likely to accrue for a community which takes care to be included in the airport development program. It will be termed progressive, there will be more patronage for community activities, local merchants will benefit, connections with airlines will help existing business and industries and may cause new industries to locate in the small town or city. Moreover, Mr. Piper believes that for the small town, limited facilities and outlays will be sufficient. He continues:

"Landing strips are ideal for the small town where immediate requirements do not warrant an airport or where sites for one are not available. Landing strips are recommended for the residential sections of larger cities as auxiliaries to their municipal airports. A landing strip can be laid out as a single straight strip or in the form of an L, or a T, depending on its location. The L-shape and the T-shape strips are the most desirable, as they will allow planes to land against the wind from four different directions. By all means have a landing strip, running into the prevailing winds, even if it can't be more than 1800 feet by 100 feet. A larger strip, of course, adds safety. One 2500 by 200 or 300 feet is desirable. A level sod field is satisfactory. Each strip should have air-marking numerals, windsock, direction pointer, and corner markers and should be close to town and the highway."

Whether in a giant city or in a small country town, the right kind of airport, located in the right spot, will come into being only if local effort supplements or complements the overall planning of the Federal Government. In our national airport program, it is the duty of civil leaders everywhere to co-operate with the Civil Aeronautics Administration, perhaps to get in touch with William P. MacCracken, Jr., of the National Aeronautic Association, chairman of a committee which is making a special study of the local airport problem.

It will also be worth while to consult the airlines, which are always ready to help For example, Eastern Air Lines has published a fine pamphlet, "Your Airport Problems," which, with a foreword by Eddie Rickenbacker, contains much sense. Airlines will also be glad to help in surveys and information. Eddie Rickenbacker recommends the formation of aircraft planning committees, charged with the duty of studying the probable volume of air traffic, of relating airline facilities with density of population, of studying the relationships between city centers, of determining whether a single jointly owned airport might not serve two or three towns better than several individual airports of lesser facilities.

Quite naturally the first duty of the local Airport Planning Committee is the selection of a site. But such groups should be warned that the selection of a site is a difficult matter, involving a number of factors. The topography of the country must be fully taken into account. The landing field should have a surrounding area which is at least partially free of obstructions. A stack 130 feet high would have to be at least one mile from the airport if the field is to comply with Civil Air Regulations. The time required for and the method of transporting passengers from the airport to the center of the city must be taken fully into account. Data must be obtained on the intensity and direction of prevailing winds as the best guide to the design of the runways. The Planning Committee should learn all it can on the prevalence of fog, snow, and the like. There must be sufficient land for expansion. It is odd that no one seems fully to appreciate how quickly aviation can grow; if insufficient land is bought at the time the airport is constructed, it may be necessary to spend huge sums for expansion afterward.

RUNWAY DESIGN IMPORTANT — The Planning Committee should, in the case of an airport of any size, employ competent engineers or architects, but professional men do their best work only when the employing body knows the job in hand well enough to exercise critical supervision. Therefore the Planning Committee should learn something of runway location and design. The length of runways should correspond to the type of aircraft likely to use the field. A runway for small private aircraft need be only half or even a smaller fraction of the length demanded for a huge airliner. The number of runways depends on the prevailing wind conditions, but if a single runway is the best that can be had it should be in fair alinement with the wind direction for at least a greater part of the time. The longest runway should be in the direction of the prevailing wind of minimum velocity.

Secondary airports do very well with runways of some 3500 feet. Runways should facilitate traffic, and if possible there should be two sets of them, one set of long ones for airline operation, and another set of shorter ones for private aircraft.

The design of airport buildings should be functional, and their layout should be such as to permit handling either passengers or cargo with ease. Another sage word of advice from Captain Rickenbacker: There should be segregation of passengers from mail and cargo handling, and separation of incoming and outgoing passengers. In any field, no matter what its size, there must be facilities for repair, for administration, for aids to flying and navigation. Distance from the passenger loading location to the terminal proper should not involve excessive walking.

Civil airports may be divided into those catering to scheduled airline operation and those suitable for private flying Some idea has already been given of the dimensions required for the simple private flying field. Airports for transport operation are classified by the CAA as follows:

Type of Community	Class	Landing strip
Small community not on carrier system, up to 5000 population	1	1800 to 2500 ft
On feeder lines, 5000 to 25,000 population	2	2500 to 3500 ft
Important cities on feeder lines and intermediate stops on main lines, 25,000 to several hundred thousand	3	3500 to 4500 ft
Major industrial centers and important junctions or terminals on the airlines	4	4500 ft and over

The accompanying sketches of a Class 2 Airport show the utmost in simplicity. The runway pattern is held to the minimum, and runways are simply arranged. Loading apron is so placed that a minimum of taxying is required. All administrative facilities and facilites for handling mail, cargo, passengers, and spectators have been lumped together into one simple building. Even in such a

simple airport passengers are segregated from spectators, after leaving the ticket window.

Larger airports may be far more elaborate, but the principles of design are likely to remain the same.

It is impossible to quote exact airport cost figures. From the $50,000 which can give a small community the nice little airport sufficient for the needs of a few privately owned airplanes, to the $100,000,000 of Idlewild there is an infinite range of requirements and prices. A Planning Committee would do well to see how much assistance it could get from the Federal or State authorities. Then it should estimate the quantities involved, such as cubic yards required for grading, square yards of paving, cubic content of hangars. Then such quantities should be multiplied by unit prices prevalent in a given locality The cost of land, the equipment needed for lighting, equipment costs, insurance, architect fees, and many other items must be taken into consideration. The final cost estimate must be multiplied by a generous safety factor. Also some attempt should be made to estimate what can be earned through leasing of hangars, by landing charges, and from various concessions

Aviation has a great future and it is not likely to be hampered by the lack of airports any more than the automobile was hampered by the lack of highways. But there is every reason why the people as a whole should give this matter of airports intensive thought without relying implicitly on the Federal Government. Moreover, they should never allow the Federal authorities to dominate in construction and operation. Advice, and allocation of funds on reasonable assurance of meeting requirements should be as far as even a well intentioned body such as the CAA should go.

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ROCKET PRINCIPLE

Being Used in a Number of Military Developments

BECAUSE the Germans have made striking use of the rocket or jet principle in their so-called "robot" planes it must not be inferred that the United Nations are lagging behind in the application of such principles. For example, the Germans do not appear to have anything to equal the Bell jet-propelled aircraft, though they have made similar experiments. The Navy has recently revealed that the Grumman Avenger torpedo planes have been equipped with rockets and have sunk submarines with such weapons. These rockets, particularly those of the larger size, deliver a tremendous blow for their weight. The Navy has also revealed recently that it has utilized the rocket principle in assisted take-offs of heavy, overloaded bombers.

The German robot plane has a range of well over 100 miles. It carries a ton of explosives in the nose of the 25-foot fuselage, which has a very small frontal area. This means that the robot is heavily loaded per square foot of wing area, and must fly fast if it is to stay up at all. Since the wings are not to account for take-off and climb, these being supplied probably by catapult and ramp, they can be small in area and low in aspect ratio, which means that the span is not so many times greater than the width or chord of the wing.

It is apparent that the craft is controlled by a gyroscopic compass and another device which actuates the elevator and possibly the rudder. The robot flies at a predetermined altitude of, say, 1000 feet This is no doubt controlled by means of an aneroid unit which raises or lowers the elevator indirectly, or perhaps reduces or increases the amount of fuel.

The range of the robot is likewise controllable, probably by means of an air log, in the form on an air-driven propeller which, as it rotates, turns gears and brings a device into play which terminates the flight after a certain number of revolutions. All these control devices do not constitute direction and distance control, since the atmosphere still comes into play, and the pressure of the atmosphere can vitiate the control of the aneroid unit, while side or head winds can ruin both direction or range

There remains for conjecture the engine of the strange craft. We can imagine that the nose of the motor carries radiator-like openings through which the air enters, because of the high speed, with a certain ram or supercharging effect. Fuel is admitted to the chamber through a simple valve, and this fuel can be kerosene or any other low grade type. It is probable that an electric spark fires the mixture. As pressure is built up, the opening at the nose of the engine is shut by the pressure, and hence the gases of combustion rush out to the rear, producing propulsion. When the explosive cycle is completed, the nose of the engine is again opened, air is again rammed into the cylinder, the spark ignites another charge, and the cycle is repeated so rapidly that the sound of the engine resembles the whir of the ordinary airplane engine.

More powerful robot planes, with radio guidance, may eventually develop into a dangerous and significant aerial torpedo of real military value, but then they will no longer be the simple, inexpensive device which it is possible to turn out in great quantities.

AIRPORT SAFETY

Offers Fertile Field for Ingenuity and Invention

THE FIFTEENTH Annual Safety Convention of the Greater New York Safety Council had interesting sessions covering safety both in aircraft manufacture and in airplane operation. At the airport, in the opinion of Walter T. Johnson, Safety Director of American Airlines, the major problems from an accident point of view are two-fold. One is air and automotive traffic control. The other involves the hazards of servicing aircraft, such as gasing operations, supplying auxiliary power, inspection on the ground, and so on. One lesson is that the less auxiliary equipment on the ramp and apron at the airport the fewer the accidents.

It is not uncommon at the airport to see a clutter of gasoline trucks, air-conditioning trucks, baggage carts, passenger ramps, and tractors in front of the hangars. In some of the newer airport designs, many of these obstacles have been removed from the surface For example, pits are being provided for the storage of gasoline, for air-conditioning service and the like, but these pits have themselves created electrical and moisture hazards

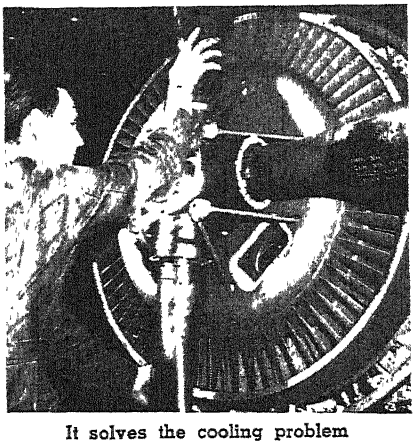
A peculiar accident is described by Mr. Johnson. The nose of a fuselage projected over a pit. The ground serviceman opened the cover and a spark from faulty electrical equipment on the aircraft caused an explosion of vapors in the pit.

There seems to be a field for ingenuity and invention in the safetying of the auxiliary equipment of an airport.

ENGINE COOLING

Facilitated by New Propeller Fan

NO MATTER how carefully cowled an aircraft engine may be, the problem of cooling its cylinders when working at full capacity is a serious one. When the aircraft in which the engine is installed is a relatively slow one, and is used for long-range cruising as are the Glenn Martin PBM-3D Mariners now



It solves the cooling problem

on patrol duty in the Pacific, the difficulty is even greater. After experiments which go back as far as 1930, Wright Aeronautical engineers have made an advance in the art of engine cooling by the development of a special fan, bolted to the propeller and turning with it, and a fixed diffuser attached to the engine. Both rotor and diffuser are riveted assemblies fabricated from sheet aluminum alloy.

As can be seen from the photograph, the rotor has a sheet metal center and vanes similar to airfoils or twisted propeller blades around the outer perimeter to force added air past the cooling fins on the engine cylinders. The diffuser has corresponding vanes so designed as to convert the speed of the air supplied by the rotor into pressure sufficient to drive the air past the cooling fins.

Better Water for Industry

Location Determines the Physical and Chemical Properties of Water Available for Industrial Use. Only Through the Application of the Best Talents of the Chemist and the Engineer Can Existing Processes be Applied to the Solution of Many Industrial Water Troubles

EDITOR'S NOTE: In our June issue, page 265, appeared an article on the general aspects of water conditioning. This aroused considerable interest and attracted many inquiries regarding water treatments for specific industrial purposes. The present article deals with industrial water treatment practice and supplements the information previously published.

WATER IS as indispensable to manufacturing and industrial operations as it is to the maintenance of life itself. But, unlike the human body which automatically adapts itself to the use of water varying over comparatively wide ranges of quality, many industrial processes require specific modification of natural waters in order to operate successfully.

A classic example of the importance of water quality to industrial processing may be cited in connection with the manufacture of Bourbon whiskey. Kentucky distillers claim that the distinctiveness and superiority of their product may be attributed in large measure to the use of processed water drawn from wells that penetrate limestone formations. It is said that only the wells near Louisville produce a water with the special attributes needed for the manufacture of Bourbon.

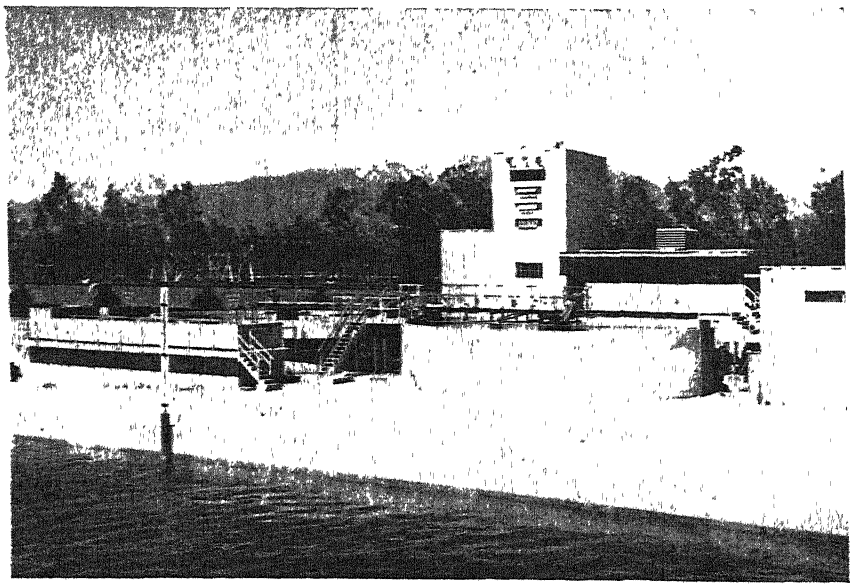
While the peculiar relationship of Louisville groundwater to whiskey processing may be debatable, it is a fact that water varies as much in its physical and chemical properties as there are locations from which it is obtainable.

There is no such thing as a natural, pure water; even the rain descending from the clouds is contaminated by contact with atmospheric dust before it strikes the earth's surface. And once it touches the ground the rain water acquires characteristics of quality that reflect everything with which it comes in contact. Thus, in a limestone region, the soft rain water quickly becomes mineralized and "hard"; in a swamp area the water displays acid characteristics and color from decaying vegetation; and rainwater that flows across a newly tarred or oiled road absorbs enough phenol to acquire a decided taste.

Considering the wide variations to be found in terrain, geology, and man-made culture, it is not surprising, therefore, that water quality characteristics should be almost infinite in number, varying not only with location but with seasonal factors as well Heavy runoff with floods, for example, will cause surface streams to be more turbid in the spring than they are during the winter months.

One of the major problems of industry is the need to condition water for its specific requirements. Hardly ever can an industry so locate its operations to take advantage of a water supply that exactly fits its need. In fact, within a single industry it may be necessary to modify water differently for each of three broad classifications—(1) cooling and condensing, (2) processing, and (3) steam generation Even the most perfect surface or groundwater sources or the supply emanating from a municipal water treatment plant cannot be expected to meet all these special needs.

Vast strides forward have been made in this special field of industrial water treatment, and there is available today equipment and processing techniques to fit virtually every need. Depending on the use to which water is put and the particular quality standards desired (see table classifying standards according to industry), there are various forms of treatment to which it must be subjected.



Water treatment unit at a California iron and steel plant built by the Kaiser Company, Inc. A complete system of reclamation and purification is used

FIVE OBJECTIVES—The objectives to be sought, as outlined by Robert T. Sheen and Lewis B. Miller, engineers of the W. H. and L. D. Betz Company, water consultants, are as follows For processing purposes water must be treated for (1) suspended solids and turbidity removal; (2) color reduction; (3) hardness and alkalinity reduction; (4) removal of iron and manganese; (5) removal or reduction of carbon dioxide, hydrogen sulfide, organic or free mineral acids.

Quality requirements for boiler feedwaters, they point out, are far less stringent for steam produced at low pressure than for steam produced in the high pressure units of the power plant There are very definite limitations in hardness, total solids, pH, dissolved silica, and so on, in the water used for steam generation which must be met if operating difficulties are to be avoided. The higher the steam pressure the more rigid and sharply circumscribed are

	Boiler Feed Water			Brewing		Canning	Carbonated Beverages	Cooling Water	Pulp & Paper					Raw Water Ice	Tanning	Textile
	0–150 lb.	150–250 lb	250 & up lb	Light	Dark				Ground wood	Kraft	Soda & Sulfite	Bleached	Rayon			
Turbidity	20	10	5	10	10	10	2	50	50	25	15	5	5	5	20	5
Color							10		20	15	10	5	5	5	10–100	5–20
Dissolved oxygen* in cc/liter	2	0 2	0													
Color plus O_2 consumed in ppm	100	50	10				10									
Odor (or free chlorine) " "				0	0	0	0							0		0
H_2S " "	10	5	0	0 2	0 2	1	0 2	5								
Total hardness ($CaCO_3$) " "	75	40	8			25	250	50	180	100	100	50	8		50–135	10
Methyl orange alkalinity " "				75	150 & up		50–100						50	30–50	135	
Ca " "				100–200	200–500											
Fe " "				0 1	0 1		0 2	0 5	1	0 2	0 1	0 1	0 05	0 2	0 2	0 2
Mn " "				0 1	0 1		0 2		0 5	0 1	0 05	0 05	0 03	0 2	0 2	0 2
Fe plus Mn " "				0 1	0 1	0 2	0 3	0 5	1	0 2	0 1	0 1	0 05	0 2	0 2	0 2
Al_2O_3 " "	5	0 5	0 05										8			
SiO_2 " "	40	20	5										25	10		
Cu " "													5			
F " "				1	1	1	0 2									
CO_2 " "	200	100	40													
HCO_3 " "	50	30	5										60			
OH " "	50	40	30										8		8	
Total solids " "	3000–1000	2500–500	1500–100	500	1000		850			300	200	200	100	300		
$NaSO_4$—Na_2CO_3 ratio	1 to 1	2 to 1	3 to 1													
$CaSO_4$				100–200	200–500											
pH	8.0 & up	8 5 & up	9.0 & up	6 5–7 0	7 0 & up											
Potability				U.S.T	U.S.T.	U.S.T	U.S.T.							U.S.T		

Values represent standard A P H.A determinations * Determination by Winkler method. U S T means U S.Treasury standards for drinking water

Standards of water quality classified as to industrial applications. From data by International Filter Company

these limitations. And failure to condition water properly may result in boiler tube losses at a time when tube replacements are difficult to secure promptly, if at all.

Regarding corrosion, Messrs. Sheen and Miller state that corrosion of ferrous materials is caused principally by dissolved oxygen, acid conditions, or by electrolytic corrosion. There are other specific conditions under which corrosion will result on certain materials. Thus a water of high pH value may be quite as corrosive as a water of low pH value on zinc or galvanizing. Ammonia will have a corrosive action on copper, copper bearing alloys, nickel, or nickel-bearing stainless steel. Mills using process water that occasionally contains salt or seawater encounter corrosive conditions due to the salt content. In many cases the cause of corrosion in a particular mill may be readily and correctly attributable to one or more of the factors described and, by proper correction, substantial reduction in the amount of corrosion may be effected.

Methods of industrial water treatment vary from simple sedimentation of a supply, secured by quiescent storage in a reservoir or tank, to the introduction of complex organic chemical conditioning agents at specific points in the plant. A typical example of the latter technique is to be found in the applications of cupric chrome glucosate, pioneered by the D. W. Haering Company, for the control of algae and bacteria growth as well as for the inhibition of corrosion.

Where sedimentation alone is not sufficient for the removal of finely suspended, colloidal, or coloring matter, coagulation is used. This process involves the addition of small amounts of an aluminum or iron salt to the water. The acid-salt reacts with the alkalinity of the water to form gelatinous precipitates. The latter enmesh the tiny particles suspended in the water, grow heavier in so doing and settle to the bottom of the tank. This treatment affords a fairly high degree of clarification when long and quiescent periods of detention can be provided.

SAND FILTER—To secure the utmost in clarification, a filter is employed following coagulation. The filter generally consists of a sand bed (18 to 22 inches in thickness) underlain by several layers of graded gravel (totalling about 20 inches in depth). The water containing finely suspended material and coagulent floc is applied on the top of the sand bed, and finds its way through the sand and gravel to reach an underdrain system. The filters may operate either by gravity flow or pressure. The latter type is housed in a steel shell tank, while the gravity flow filter is built in the form on an open, concrete box. Removal of the foreign matter in the water occurs at the surface of the sand bed, which is cleaned periodically by backwashing This is accomplished by simply reversing the flow of water through the filters; the upward flow expands the sand beds and then washes away the material on the surface.

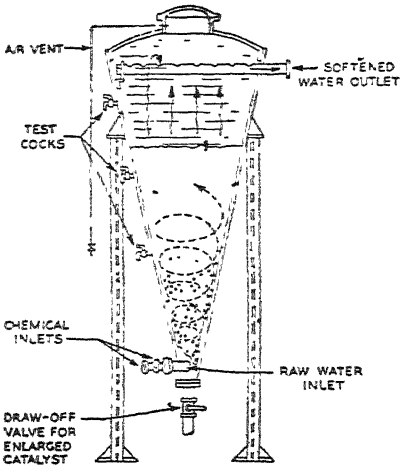
Sedimentation, coagulation, and filtration are processes that remove suspended matter, turbidity, and color and reduce the bacterial content of water. The removal of substances that cause so-called hardness—principally calcium and magnesium salts—calls for the use of water softening processes.

Several methods of water softening are in vogue, including lime-soda precipitation (hot or cold), and base-exchange processes (zeolite treatment). The cold lime-soda treatment operates on the principle that these chemicals added to water containing calcium and magnesium carbonate, bicarbonates, and sulfates will react to form precipitates and thus settle out in the form of a sludge. In the older treatment plants this reaction was carried out in an ordinary tank. A much more efficient device, known as a Spaulding precipitator, is now available for this purpose.

The precipitator is a cone-shaped tank inside of which is suspended an inverted cone-shaped baffle. With this arrangement and a motor-driven agitator it is possible to maintain a "blanket" of pre-

cipitated sludge through which incoming water must pass. Thus the water to be treated is brought into more intimate contact with the chemicals and the result is a more efficient and economical softening operation than that obtained in a plain tank.

A more recent development is the Spiractor, a device by means of which a catalytic agent is used to accelerate softening reaction. The Spiractor process employs a conical shaped tank slightly more than half filled with fine granules of calcium carbonate catalyst Raw water enters the bottom of the



The Spiractor cold lime softening process developed by the Permutit Company. Water enters at the bottom of the tank, circulates upward through a bed of granular catalyst, and emerges as softened effluent

tank through a special fitting containing a tangentially disposed nozzle. Through another opening in the fitting, the proportion dosage of lime suspension is pumped. This mixes with the upward swirling water, the flow rate of which is high enough to maintain the granular bed in a suspended condition and low enough to avoid carrying any of the granules over the top of the tank.

The immediate contact of the chemically treated water and the suspended catalyst granules greatly accelerates the softening reaction between the added lime and the hardness content of the water. Relatively insoluble reaction products are formed while the water is still in contact with the granules and these deposit on the surface of the granules in the form of successive, firmly adherent layers.

Not only does the process give fast action (normally a 5 to 10 minute detention period) with resulting economies in size of plant, but the end product is a granular substance quite unlike the sludge normally produced by lime treatment.

The hot lime-soda technique for water softening is used only for the treatment of boiler feed water. It is similar to the cold process in that it uses the same chemicals; however, the reactions are carried out at or near the boiling point of water. Exhaust steam is used for heating the water prior to the addition of the chemicals and since the effluent from the settling tank and filters is hot it can be fed directly to the boiler. One of the principal advantages of the hot process is that the chemical reactions proceed more rapidly at higher temperatures and more complete reactions are obtained. Also, part of the hardness (bicarbonates of calcium and magnesium) is removed when the water is heated.

One of the most popular methods of softening water for industrial use involves the use of zeolites. These are complex, insoluble mineral compounds, similar in size to coarse sand, which are found in natural deposits or can be manufactured synthetically. [See page 265, June Scientific American.—*Ed.*]

One of the more recent developments in zeolite processing comes about by the availability of a non-siliceous zeolite that is equally effective in removing both carbonate and non-carbonate (sulfate) hardness It is composed of a sulfonated organic material that operates either on the sodium or hydrogen cycle of base exchange. Operated on the sodium cycle, it takes out carbonate hardness and is regenerated with salt, the same as the older forms of zeolite.

When it is operated on the hydrogen cycle, this zeolite removes sulfates and chlorides as well as the bicarbonates of calcium, magnesium, and sodium (in the latter case leaving nothing but the carbon dioxide which can be removed by aerating the water). Regeneration on the hydrogen cycle is accomplished with dilute sulfuric acid.

Iron and manganese, as well as hydrogen sulfide, are found in water. The latter is extremely troublesome because it imparts corrosiveness, while iron and manganese contribute to many processing difficulties. Aeration followed by filtration is a frequent method of treatment for removal of iron and manganese; these substances are thus oxidized and removed by the straining action of the filter. Zeolite treatment for softening also aids in the removal of iron and manganese.

Hydrogen sulfide can be removed by aeration but where this proves inadequate it becomes necessary to use degassifying equipment of special design.

This brief discussion of industrial water treatment practice illustrates the many techniques that are available for conditioning water to meet virtually any need. It must be emphasized, however, that the application of these techniques calls for specialized knowledge far beyond the ken of the general plant superintendent or maintenance engineer. Even the experts admit that industrial water treatment is a complex science calling for the best talents of the chemist as well as the engineer.

WATER FILTERS

Designed for Army, Uses Cake of Diatomaceous Earth

DIATOMACEOUS earth has been found to provide an ideal filtering medium for purifying water for army troops in the field, according to recently released information from the Engineer Board of the Corps of Engineers The need for better filtration equipment arose from the failure of standard sand filters to remove cysts of *Endamoeda histolytica*, one of the causative agents of dysentery.

The filter equipment consists of a series of cylindrical, porous refractory elements suspended in a metal shell. Upon such an element a cake of diatomite, (one of several forms of diatomaceous earth) is deposited by circulating slurry through the unit. When deposited, the cake is built up to a thickness of 0.06 to 0 09 inch. This cake is the filter medium through which the water passes and upon which suspended matter and bacteria are deposited. Backwashing of the filter to remove suspended material trapped in the filter cake is accomplished by reversing the flow of water through the filter.

Two sizes of diatomite filtration equipment have been produced for field use. One has 3.6 square feet of filter area, with a nominal capacity of 15 gallons per minute, suitable for pack transport and weighing 50 pounds. The other has 10 square feet of filter area with 50 gallons per minute capacity.

WATERWORKS COST

Can be Based on Analysis of Contract Data

A YARDSTICK for approximating the cost of a waterworks system—and a recent survey indicates that our postwar agenda should provide for new waterworks in almost 5000 communities—may be fashioned from data collected by the Public Works Administration.

In the period 1933-39, the PWA participated in the construction of 781 complete water supply projects. An analysis of the contract data shows the following average cost per capita, arranged in three population groups.

Population Range	Avg. Cost per Capita
100 to 500	$84.00
500 to 1,000	65.00
1,000 to 10,000	45 00

Construction prices have risen since the above data were compiled, and the present per capita cost should be increased by about 32 percent to conform with present-day prices.

MAGNETIC SWEEPERS

Used by State Highway-Patrol Trucks

ELECTROMAGNETS attached to highway patrol trucks in North and South Dakota collect as much as 12½ tons annually of nails, bolts, and other small pieces of metal that fall on the road surface. In North Dakota the average yearly collection is about 6¼ pounds per mile, while in South Dakota it averages only 1¾ pounds per mile.

It is conservatively estimated that for each pound of scrap collected the motorist is saved $4.80 over and above the cost of collection. This figure is obtained by assuming that each pound of metal left on the road would cause ten punctures, each of which would cost about 50 cents to repair.

The Resin Dog with the Plastics Tail

Quick-Drying Enamels, Better Plywoods, and Improved Fabrics, are Only a Few of the Developments of the Synthetic Resins Industry. Plastics Aside, These Resins are Doing Jobs that Have Immediate and Long-Range Implications to a Number of Industries and to the General Public

IN THE overall field of synthetic resins, molded and sheet plastics have become the tail that wags the dog. The plastic bomber noses and gun turrets on our fighting planes; medical instruments that pipe curved light; furniture and tableware; jewelry and novelties, have caught the public eye, and the layman feels that these plastics are the whole resin story. Actually, many invisible resinous miracle-makers—alkyds, urea, melamine and phenol formaldehydes, vinyls, acrylics, and maleics—preceded the moldable plastics, take in a larger scope, and have an equally impressive record.

Synthetic resins make possible the "four-hour" enamels, and they are now responsible for the completely weather-, water-, and fungus-proof plywoods, replacing vitally needed war-time metals —a feat which remains one of the outstanding material developments in the war. In almost every conceivable field of production, these resins see active service: in flexible adhesives, caulking compounds, gas-resistant coatings, aircraft lacquers, life rafts, army raincoats and tent cloths, weatherproof fiberboard for shipping containers, and protective coatings for hard-working Navy vessels and weather-abused Army tanks and jeeps. Also in service on the home front, they make brake-linings wear far longer, prevent spoilage of medicinal enzyme preparations, help to purify drugs, make tougher grinding wheels, recover precious metals from industrial wastes, increase sugar yields, purify water, and reclaim valuable tartrates from grape wastes. But in each case the resins are more or less invisible, their work more or less unknown, and their share of the spotlight dependent upon their more gaudy colleagues—the plastics.

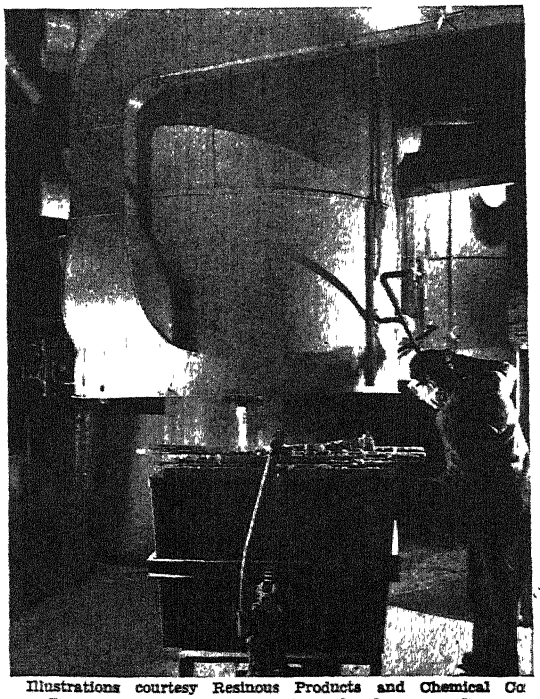
Credit for bringing these invisible wonder-workers to their present industrial status cannot be pinned on any one firm. While many resin-makers were dazzled by the vision of a plastic molded world, some few research groups concentrated on other-than-molding uses for resins. In 1924, for example, one of these groups, the Resinous Products and Chemical Company, presented the paint industry with a synthetic resin that made possible fast drying paints and inaugurated a period of spectacular growth in the resin industry. This was many years after Dr. Leo Baekeland first sought a shellac substitute in phenol-formaldehyde reactions but sidetracked his original quest when his "shellac" turned out to be a miraculous molding material.

Prior to 1934, most plywood was produced in this country with the aid of animal and vegetable glues. Because of the susceptibility of such glues to moisture, vermin, and mold growth, plywood tended to separate at the plies and deteriorate altogether too rapidly to make it a satisfactory structural material.

With the development of special phenol-formaldehyde resins, plywood emerged as a new structural material of almost unlimited versatility. The introduction of these new glues made great changes in the technique of plywood production, making it simpler and faster. The adhesive was supplied in sheet form in continuous rolls which could be cut to fit the size of any plywood assembly. This eliminated the need for spreading liquid glue on veneers and made possible the very thin plywood used on airplanes today. Whereas the older glues depended upon drying out of water for adhesion, this resin film, after being inter-leaved between veneers, was placed in a hot press where the combination of heat and pressure fused the wood and resin into plywood which was proof against continued boiling in water. The manufacture of plywood was cut from hours to minutes by this method and the hot press installations in plywood and woodworking plants increased from 13 to over 225 in the past decade. For the first time, completely waterproof resin-bonded plywood became available for aircraft, boats, housing, transportation, radios, furniture, musical instruments, and scores of other new uses.

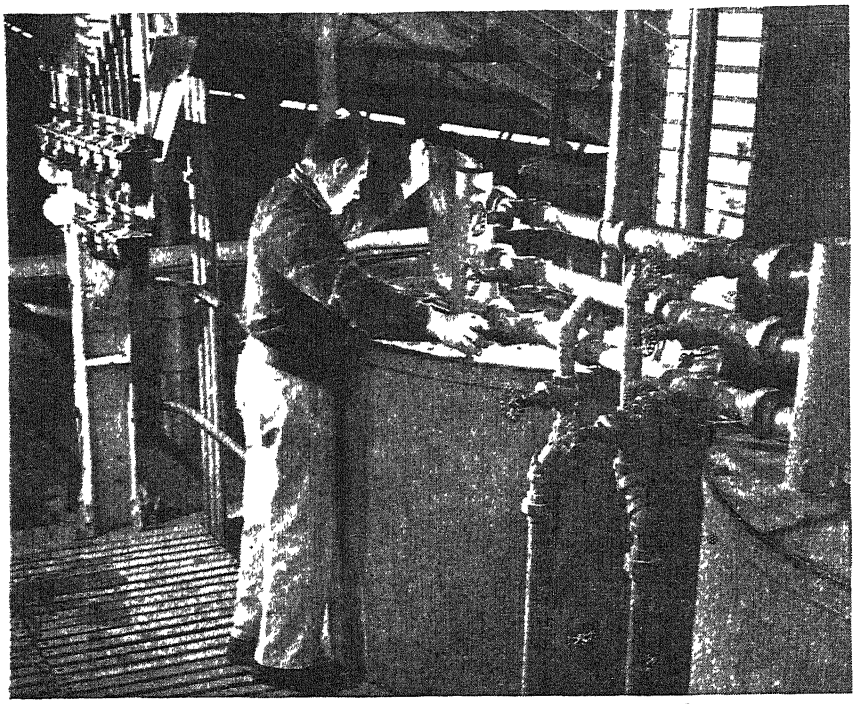
As the demand for resin-bonded plywood grew, thought was given to the production of plywood without the use of hot-pressing equipment. Among the first successful resins which have thus tremendously expanded the development of resin gluing were a group of urea-formaldehyde resins. As in the case

Testing strength of plywood glue



Illustrations courtesy Resinous Products and Chemical Co

Coating resins dropping from kettle to cooling vats when correct reaction has been reached



Checking resin condensate in supply kettle for spray drier

of the film, the resin glue line produced with these resins is stronger than wood itself, and is highly resistant to moisture, vermin, and mold. These resins are produced as dry, water-soluble powders and as aqueous solutions.

Suitable catalysts or hardening agents are used to control the working life of the glue and to accelerate its setting after application to the gluing surface. After these glues are set they cannot be softened by exposure to water or heat.

Prior to the war these adhesives were most widely used in the manufacture of the better grades of furniture and radio cabinets. They are produced in neutral color, thus eliminating staining difficulties, particularly with light-colored woods and thin veneers. During the war a large part of production of the phenol formaldehyde and urea formaldehyde resins have been utilized as assembly adhesives for plywood aircraft construction, wood life rafts, boats, cargo bodies for trucks, timber structures, and so on. The advances in the molding of plywood by flexible pressure rather than rigid pressure plates made complex curved forms possible. Used to curve irregular shapes or for pieces requiring curves in more than one plane —such as the egg-shell shape required for airplane "drop-tanks"—this method employs an inflated or deflated bag as one of the halves of a pair of molding dies. After layers of veneer are wrapped on a concave mold, an inflated bag may exert pressure on one side, or the veneer-covered mold may be placed inside an open-mouthed bag, the bag deflated so that it adheres to the contours of the mold, and the whole inserted into an autoclave, or "pressure cooker," where heat and pressure are applied by steam.

SYNTHETIC RAINCOATS—When parts for planes, tanks, guns, and similar military equipment are packed for overseas shipment, they are coated with a sprayed liquid synthetic resin that wards off destructive effects of salt water corrosion.

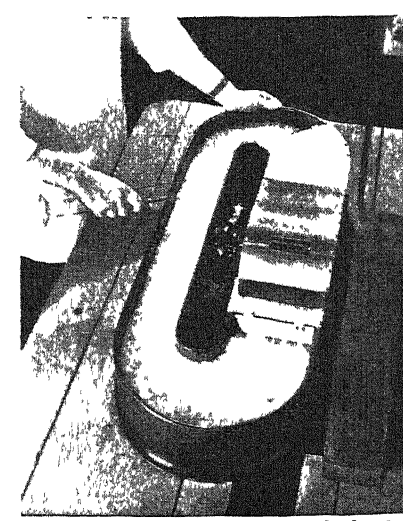
The acrylic resins are used to waterproof military maps, to eliminate polishing of brass and copper, to preserve art treasures, and to make possible luminescent paints which are used on gunsights for jungle fighting and to illuminate submarine instrument panels, aircraft dials, road markers, and air-raid shelter signs.

Other resins, water-dispersed acrylic ester polymers, go into leather coats for aircraft pilots, making the leather grease-proof and eliminating the fire hazard coming from grease-soaked clothing for pilots forced to parachute from a burning plane. Not only is this leather fire resistant, but it is also unaffected by the intense cold encountered in high altitude flying. It remains tough and flexible.

Still another recent accomplishment in the synthetic resin field has been increasing the wet strength of paper The resin most widely used is of the urea formaldehyde family. The lack of color, odor, and taste, resistance to mold and fungus, ease of handling in paper processing, and chemical resistance of these resins in final insoluble form have given the paper maker a tool that enables him to make wide use of less expensive and more readily available pulps. One of these resins, specially tailored for the paper-making process, may be added at any accessible point on the paper machine prior to sheet-formation, preferably at the beater. The required ratio of resin to paper is so small that the appearance and feel of the sheets is practically indistinguishable from ordinary paper, but the paper's wet strength is increased as much as ten times. Soft absorbent paper toweling may now be used like a cloth without fear of its tearing into shreds. In the blueprint and photographic paper field, the dimensional stability of the resin treated paper under varying conditions of temperature and humidity has proved particularly useful. Not only is wet strength increased in paper treated in this manner, but dry strength as well—measured in terms of the standard tests of tensile strength. Disposable garbage buckets, frozen food packs, cloth substitutes, and camouflage papers may be mentioned among the many uses of resin treated papers.

Another problem of the paper industry was solved with urea-formaldehyde resins. Fiberboard is made by gluing together, under pressure, sheets of paper to form a heavy, strong laminate. Corrugated board is the familiar carton stock consisting of a fluted paper center with outer plies of heavy paper. While both of these types are very strong when dry, exposure to dampness causes them to become soft and upon continued wetting the plies may separate, as the ordinary glues used offer little resistance to moisture. The need for fiber packing cases which would be weather-proof and more suitable for exposed storage and overseas shipments necessitated the development of an adhesive which would not fail when wet Urea formaldehyde resins, when used in combination with dextrin or starch, make possible low cost weather-proof fiber shipping containers which hold together in wet sand or the dank holds of ships and, at the same time, because of their light weight, permit additional tons of precious cargo to be carried in ships bound for combat zones. These containers have been so toughened by the addition of the urea resin that it is actually possible to float them to beaches in the surf—a stunt that would almost instantly ruin the best pre-war shipping carton

RESINS TREAT FABRICS—Other synthetic resins have become standard for use in coating lacquers applied to fabrics to produce oil cloths, tarpaulins, raincoats, bridge-table covers, and artificial leather. In each case the fabric acts as a backing or supporting material for a continuous, heavy lacquer film. For the modification of textile fabrics, the



A laboratory model of a pulp beater in which urea formaldehyde is added to various pulps in studies to determine the effect of such additions on wet strength of paper

resins are impregnated into the fiber and may impart to the fabric improved properties of crush resistance, luster, strength, and resilience. However, the appearance of the fabric is not altered and the fabric retains all of the properties of a textile—characteristic porosity, absorbency, elasticity, flexibility, and serviceability.

In the development of urea-formaldehyde resins in the industrial finishing field, it was found that, by combining urea and formaldehyde chemically with a third ingredient, alcohol, the solubility characteristics of the resin could be so changed that, instead of mixing easily with water, it preferred instead the solvents commonly used in lacquers and enamels.

Urea formaldehyde resins are particularly well suited for use in combination with alkyd resins in the surface coating field. The two types of resin supplement each other, bringing out in the film the most desirable properties of each. Combinations of these resins have found wide use in the production of "synthetic porcelain" enamels—for refrigerators, washing machines, stoves, sanitary ware, and in many other industrial finishes where exceptional whiteness, marproofness, chemical (particularly alkali) resistance, and durability are desired.

Another kindred resin, closely related chemically to the urea type, is the "melamine-formaldehyde" resin. This resin resembles urea formaldehyde in many respects but is favored in certain applications because of its outstanding heat resistance—a characteristic readily apparent in the maintenance of gloss and whiteness in stove enamels.

VERSATILE VINYLS—Equally remarkable are the accomplishments of the vinyl resins. Recent booms in their development have come from increasing demands from industry for corrosion-resistant rubber-like materials. As a group they cover the thermoplastic field in clear, translucent, and opaque forms from hard molding resins through tough, flexible, rubber-like products to soft casting gels. They make excellent adhesives for cloth, paper, glass, and metal. They are also used as textile, paper, and leather finishes, electrical cable coatings, flexible solvent-proof tubing, and chemically-resistant metal finishes.

Still another type known as "ion exchange resins" has made possible the elimination of sugar juice impurities, removing from 60 to 80 percent of the non-sugars and 50 to 90 percent of the color from clarified sugar juices. These ion exchange resins have found wide use in the purification of the great volume of water used in the emulsion polymerization step in synthetic rubber production. One of their newest applications may be the recovery of amino acids from meat waste, soybean meal, and similar inexpensive sources. Amino acids, plentiful in meats and essential to a well-balanced diet, are expected to go far toward ridding war-torn countries of dietary deficiencies. Their recovery has long been an expensive, complicated process, but this new recovery method contributes much to a practical plan of fortifying carbohydrates with these vital acids.

The ancient alchemists hoped to accomplish feats such as the transmutation of the elements to turn base metal into gold, a hope which the fathers of modern chemistry considered absurd. Yet, many of the problems which they posed have been solved by the research of chemistry. The scientist of today is the alchemist of yesterday, transforming substances of nature into new and better products Particularly is this true in the case of synthetic resins, a vast array of products contributing to almost every phase of present-day living

RESINS AVAILABLE

Can be Put to Use by A Number of Industries

WITH THE removal of Vinsol resin and Truline binder from allocation by the War Production Board, these materials are now available to industry for all uses, it is announced by Hercules Powder Company.

During the period of WPB allocation, Vinsol resin was used in asphalt emulsions for the construction of Army airports and roads in this country and overseas, and also in the manufacturing of plastics and paperboard, to replace the use of strategic metals.

Prior to being placed on allocation, Vinsol resin was used in the manufacture of paperboard, plastics, air-entraining Portland and masonry cements, emulsions, paint and varnish, linoleum, rubber, ink, adhesives, and leather.

Truline binder finds uses in cores and molds by foundries producing castings of all metals and will extend supplies of less available materials, such as cereal binders and linseed oil

HARD-WATER SOAP

Produced by Addition of New Ingredient

TO HELP the Army keep clean, even when it has to wash in cold sea water, a new soap ingredient has been developed from petroleum by the Du Pont Company. Mixed with the other constituents of soap in a proportion of about one to two, the new material will remove dirt, oil, and grease in any kind of water, salt or fresh, cold or hot, hard or soft.

After the war, variations of this soap formula will be available for household use—some as toilet soaps and others for the kitchen and laundry. They will lighten the task of washing greasy pans, will make glassware sparkle, and will quickly erase road film from your car. This type of soap lathers well and leaves very little "ring" around the tub.

The new ingredient is a synthetic detergent, or "soapless soap." It is a sulfonated product which is sold to soap manufacturers, who use it in the manufacture of toilet soap.

The reason ordinary soaps do not work well in hard water arises from the fact that they contain sodium or potassium and the hard water contains calcium and magnesium. When the soap is mixed with the water the sodium or potassium is pushed out of the soap molecule and is replaced by calcium and magnesium. The reaction creates an insoluble calcium or magnesium compound, which is precipitated as a sticky curd—the ring around the tub or washbasin. Not until all the calcium and magnesium is precipitated and the water thereby softened will ordinary soap produce lather and do a good cleansing job. When it unites with hard-water minerals, the new soap forms not a heavy curd but a very finely dispersed precipitate, which remains suspended in the water and does not interfere with the soap's quick and efficient cleansing job

NEW THERMOPLASTIC

Can Be Boiled or Sterilized and Retain Strength and Shape

THE FIRST thermoplastic ever developed that can hold its shape and strength in boiling water and yet can be molded by the fastest, most economical methods, is known as Cerex. This new plastic opens up an entirely new field of industrial and household applications by virtue of its ability to withstand sterilization.

Produced for some time on an experimental basis by Monsanto, the new plastic has already found wide use in war work, particularly Radar, radio, and other military electronic equipment where substances of light-weight and suitable electrical and heat-resistant properties are in demand. It is also in demand for surgical instruments, aircraft instruments, and many other war applications. The entire production is now going to war work. After the war, an equally wide range of civilian applications is possible wherever high heat-resistant qualities are in demand such as in dishes and utensils which are subjected to boiling water.

FADE-PROOF RAYON

Results from Development of New Dyeing Method

A NEW method of dyeing acetate rayon fabrics which gives such fabrics dyed in a number of colors a high degree of resistance to atmospheric gas fading, has been developed by the North Carolina Fabrics Corporation, in co-operation with technicians of the American Viscose Corporation, rayon producers and dyestuff manufacturers.

Fading of colors caused by acid gases given off from fuel combustion and other sources has been a cause of frequent complaint in the past.

To date a line of six colors has been developed, all of which show no fading or color loss after 60 hours' exposure to atmospheric gases under test conditions. They are also resistant to sunlight and perspiration. Additional colors are being developed as rapidly as conditions permit.

If You Can't Kill It, Isolate It

Today There are Ways of Reducing Destructive Vibration in Machinery but These are Limited, and Thus Isolation by Means of Elastic Suspensions has a Wide Field of Application. The Design of Mountings Using Rubber for this Purpose has Now Reached the Stage of a Predictable Science

By H. H. FINK

Product Design Engineer, The B F Goodrich Company

VIBRATION, uncontrolled and unleashed, is the greatest single destructive power that confronts mankind. It is always present and constantly reveals itself in one form or another. Every single movement made by any person or any thing is motivated by a force which creates vibration or is created as a result of vibration.

The ultimate desire of every modern design engineer is to obtain maximum energy output per unit weight of producing equipment. This constant striving for weight reduction has of necessity made the engineer conscious of a class of vibratory forces heretofore given little consideration. Every piece of rotating or reciprocating machinery when in operation has some inherent or impressed unbalance which produces alternating accelerations of the moving masses. These alternating accelerations create alternating forces in the machine and in the supporting structure, resulting in an undesirable oscillatory movement commonly known as vibration.

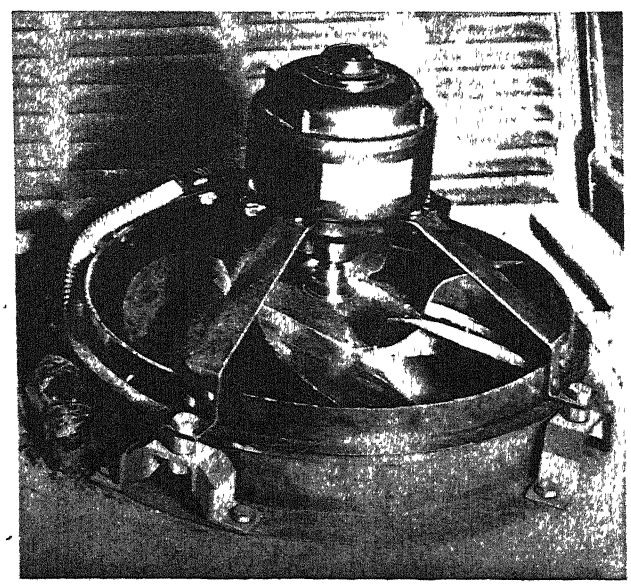
Vibration is accompanied by numerous detrimental effects which are both wasteful and costly. A machine's serviceable life is materially shortened by an increase in internal stresses resulting from vibration. Since a machine must supply the energy necessary to maintain vibration, its efficiency is greatly reduced. Because of the transmissibility of vibration through supporting structures, it may be detrimental to other machine operations, thus interfering with the micrometer accuracy which is so essential in modern processing. It also induces noise, human discomfort, and fatigue.

Several plans of attack are available in the battle against these destructive forces. Vibration created by static and dynamic unbalance of moving parts can be reduced at its source by means of mass balancing. Although this method is employed to some extent in every piece of rotating equipment, the degree of perfection attainable is necessarily dictated by the element of cost. Also, mass balancing cannot eliminate torsional vibrations due to power impulses from internal combustion engines.

Dynamic absorbers may be used, consisting of tuned elastic systems added to the original vibrating system to absorb the energy of vibration. However, they are not applicable to variable speed disturbances and therefore their usefulness is somewhat limited.

The last and most desirable method of approach to the problem is to isolate the machine by means of an elastic suspension. This type of isolation is suitable for variable speed disturbances and therefore has an unlimited field in reducing vibration effects.

Fundamentally, the principle of vibration isolation by means of an elastic suspension is very simple. A machine which is a source of noise and vibration may be suspended on springs so chosen and arranged that the machine may move freely without appreciably disturbing its foundation. The ideal condition may be visualized as a machine suspended in space. If an alternating force acts on the body, the inertia of the mass is the only force available to resist it. Therefore, the entire mass is accelerated through a small vibratory motion. Practically this is not possible but, by using an elastic suspension, this ideal condition may be approached. If the suspension be made soft enough, the inertia resistance of the mass cannot follow the quick changes in direction of the accelerating force, with the result that the mass remains practically stationary. Thus the only force transmitted to the foundation is the spring force carried through the suspension as it oscillates with the movement of the suspended mass. Without an elastic system interposed between the mass and the support, the entire vibratory force would be directly transmitted to the foundation.



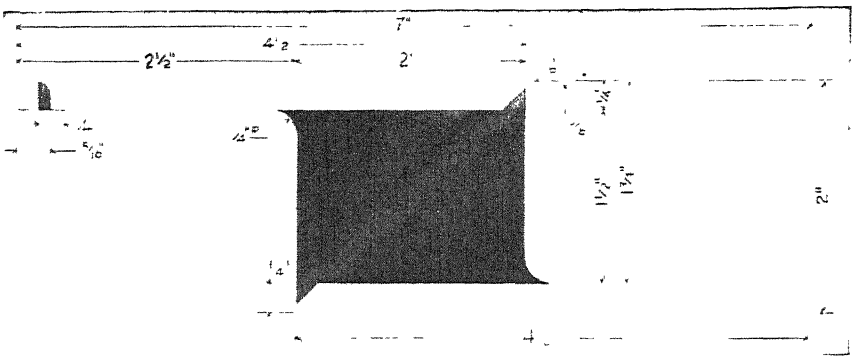
An exhaust fan mounted on rubber Vibro-insulators of the shear type. The rubber is strongly bonded to the metal parts

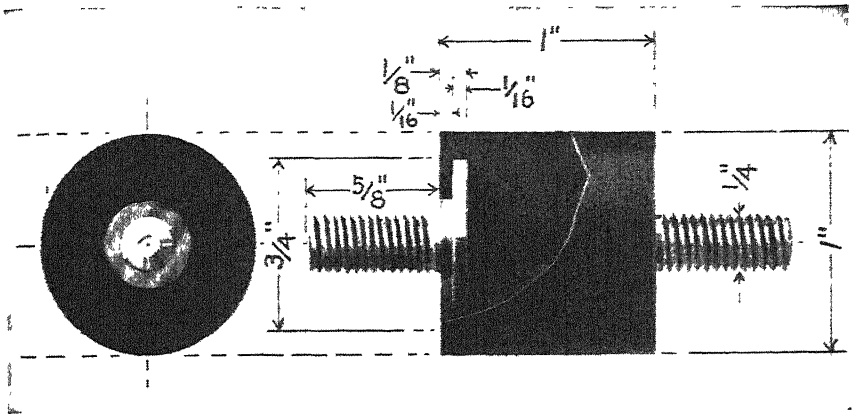
UNDERSTANDING IT—In order to understand the principle through which the installation of an elastic suspension cushions impacts, reduces vibration, and eliminates noise, it is necessary to consider first the "natural frequency" of the machine-mounted suspension, and second the "disturbing frequency" of the vibrations or impacts that originate in the machine. The natural frequency is the number of movements which occur in a unit time-element when the suspended machine is given a single impulse. Natural frequency varies with the amount of load suspended and the physical characteristics of the type of suspension.

The disturbing frequency is usually the number of revolutions or impacts per unit time-element of the machine that creates the disturbance. Many machines produce disturbing vibrations in more than one frequency. In such cases the lowest frequency is the one to be considered when selecting an elastic suspension. Any spring that satisfactorily isolates the lowest frequency will be still more effective with the higher frequency vibrations.

When there is considerable difference in these frequencies, the disturbance may be

either isolated or cushioned. Should any of the vibratory forces happen to occur in step with one of the natural frequencies of the suspended machine, it would vibrate excessively in one or more directions. Vibrations of that frequency would be amplified at the foundation unless means were provided to dampen them. The amplifying effect is analogous to the well-known case of the pendulum, wherein a very small force repeated at the correct interval of time may gradually increase the swing of the pendulum from very small to very large amplitudes.





Above: This insulator may be used in shear or in compression. Used endwise, in shear, its deflection may be an inch. Left: This type is for use only in compression

Careful consideration must be given to the proper design and location of the mountings if the elastic suspension is to be effective. It is highly desirable to obtain a layout in which the various vibration nodes act independently of each other. This requires that the mountings be placed as nearly as possible in a plane containing the center of gravity and the axis of oscillation. An independent suspension of this type allows alternating accelerating forces in a translational direction to produce true translational motion, and those in a torsional direction to produce true torsional motion. Also, it permits maximum flexibility with a minimum loss of stability, and is thus desirable in mobile installations where shock and abnormal accelerations are prevalent. If an independent suspension is not used, the translational and rotational motions combine, resulting in a complex movement of the machine. The resulting frequencies are quite complicated and the machine stability is greatly reduced. When it is not possible to mount equipment in an independent manner, and where horizontal external forces exist, it may be necessary to prevent objectionable rocking or swaying by the use of radius rod attachments or similar flexible means.

RUBBER AND STEEL—The design of mountings, to fit the selected type of suspension and to have the proper loading characteristics, requires careful consideration in selecting a springing material. Of the numerous materials available for use as isolating mediums, rubber and steel appear to be the most outstanding.

Cork and felt, although used extensively for sound isolation, have limited applications in the field of vibration isolation because of the extreme loads necessary to obtain large deflections. The high damping and sound isolating qualities of these materials make them a useful counterpart of steel spring suspensions.

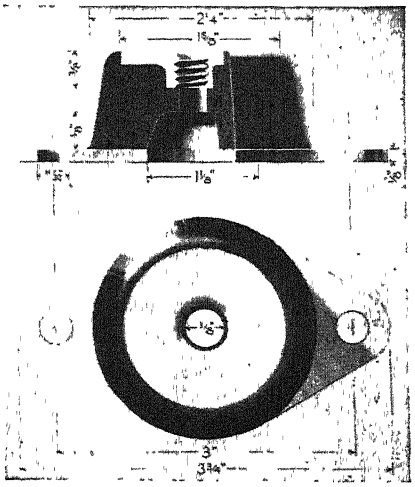
Steel springs have had the advantage in the past, because they were able to isolate a larger range of vibrations due to the greater deflections obtainable through versatility of design. They are not affected by oil or temperature changes and have a long serviceable life. However, because of their low damping factor, it becomes necessary to add an external means of damping for resonant conditions. Their lack of stability without external means of support, together with their high sound transmitting qualities, is a definite disadvantage.

Rubber used as a springing material has many advantages. It has high resilience, a small degree of inherent damping which is beneficial at resonant conditions or when sudden impulses occur, the capacity for storing large amounts of energy per unit volume, and excellent sound isolating qualities. Rubber springs have a lack of static friction and require no lubrication. Rubber can now be fabricated into economical and effective springs and can be designed to control the stiffness and stability in any direction by means of the shape characteristics. Recent developments in versatility of design now permit large deflections where previously small limitations were imposed. The life expectancy of rubber springs can be long if they are properly compounded, designed, and cared for.

It is true that rubber is affected by contact with oil and by temperature changes. Synthetic rubbers would be more suitable in this respect. The creep and damping properties of rubber vary with load, temperature, and frequency. Also, the dynamic properties differ somewhat from the static properties. However, on an overall basis of comparison, rubber appears to be the most suitable springing material for elastic supports.

Rubber can be used as a springing material when loaded in tension, compression, or shear, since the deformations are great under any of these methods. The type of installation, available space, direction of forces, freedom of movement, and physical characteristics required in the mounting will dictate the proper selection, since each method has its advantages as well as its disadvantages. Rubber loaded in tension has been given little consideration in the mounting of engines because it is easily damaged, resulting in progressive tear and ultimate premature failure.

Rubber loaded in compression was possibly the first method employed in the suspension of engines. The load-carrying capacity is very high, but the rate of stiffening is also very great. Thus the compression modulus and, consequently, the elastic restraint are variable functions. The deflection characteristics not only depend on the hardness of the compound but also on the size and shape of the mounting. For maximum service life, the deflection of rubber used in compression is usually maintained below 20 percent of the undeformed thickness. Present-day applications use this method primarily as a counterpart of the design of shear type mountings where snubber action is desired. The



A type of mounting suitable only for use in compression, as on fans

rubber can be so proportioned to give any degree of build-up resistance to overloads.

A BIG INCREASE—With the advance in the development of rubber-to-metal adhesion, the use of rubber in shear has increased tremendously. The deflection characteristic in shear is, for all practical purposes, a straight line function throughout the working range, and therefore the shear modulus is constant For the same unit loading and thickness, rubber in shear has six or more times the deflection of rubber in compression In other words, the same deflection in shear could be accomplished with less than one sixth the amount of rubber necessary in compression. Although the variable size and shape factor precludes any rigid rules of design, it may be generally stated that, for normally stressed applications, shear type rubber can easily carry loads ranging from 50 to 100 pounds per square inch on the bonded area, as the ultimate bond strength is approximately 300 pounds per square inch. Good practice limits the deflection of shear type mountings to two thirds of their thickness and the thickness is limited to that of the smallest dimension of the bonded side, or a maximum of two inches. This insures uniformity of cure as well as stability.

In the design of rubber mountings, the three types of loading cannot be considered independently of each other, for a mounting may function in shear in one direction but any forces perpendicular to the shear plane place the rubber in compression, and vice versa By a combination of all three methods of loading—that is, tension, compression, and shear—it is now possible to design rubber springs for almost any desired loading conditions Stability or lack of stability can be incorporated as required. There are two basic designs from which the more complicated mountings are fashioned. These are the elementary compression and shear types as shown in Figure 1 A few of the more common combined designs are illustrated in Figures 2 and 3.

Series mountings, whether they be compression or multiple shear plate types, as well as the double shear plate, are designed to obtain large deflections and, at the same time, retain stability These styles are soft in all directions in the shear plane, but are stiff in the one direction of compression.

The tubular and multiple tubular shear type have the advantage of being soft in one direction only, that of shear They are quite stiff in all directions in a plane perpendicular to the shear axis.

The annular and multiple annular torsional types are also a one-directional style They deform little under any radial load but are relatively soft in torsional shear By means of torsion arms, large deflections can be obtained. This design has the advantage that the rubber forms its own bearing and is capable, moreover, of sustaining great loads.

The angular torsional shear type is normally soft in two directions. The versatility of design possible with the multiple angular torsional shear arrangement as shown is very far-reaching. This design permits a wide range of physical characteristics by slight alterations in the dimension of the rubber thickness, rubber diameter, or of the length of the interconnecting arm Extreme deflections can be secured, if desirable, under very light loads and freedom of movement is obtainable in all directions.

The design of rubber mountings can now be classified as a predictable science and placed in the same category as that of steel and other structural materials. The advances made in recent years by the rubber technologist and research engineer have removed the mysterious air that once surrounded rubber The rubber industry is now prepared to collaborate on any problems involving the isolation of noise, shock, and vibration.

IN SUM—Our problem of isolating machinery thus resolves itself into a four-point program: First, the degree of isolation necessary to obtain ultimate performance must be established. Second, an analysis of the machine characteristics and a determination of the type and degree of vibration disturbances must be made. Third, from these, the proper spring stiffnesses must be calculated and the type of suspension selected. Fourth, the individual mountings must be designed not only to fit the points of support but also to give the desired and necessary loading characteristics

Having accomplished this, the engineer can take pride in the fact that another forward step has been made toward defeating the destructive power of vibration

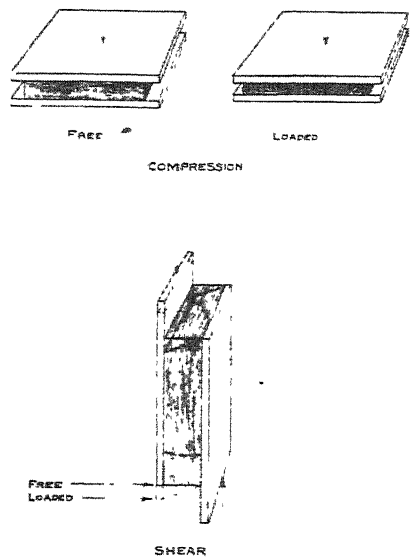


Figure 1: Above: The two basic, elementary designs

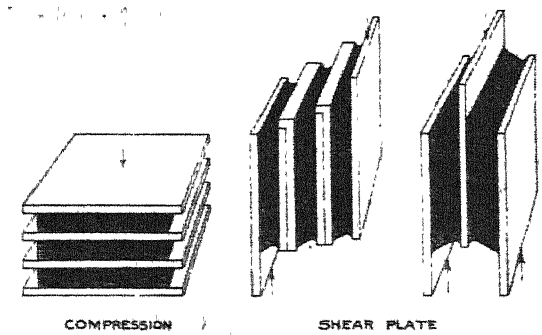


Figure 2: Left: A variety of compound mountings

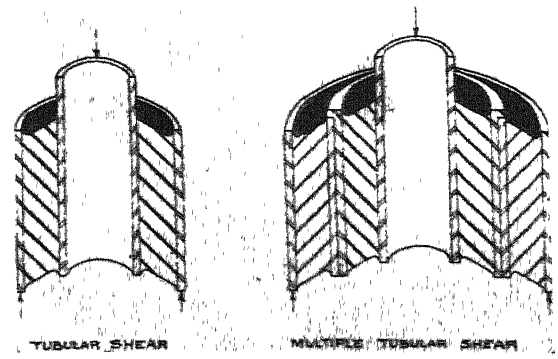
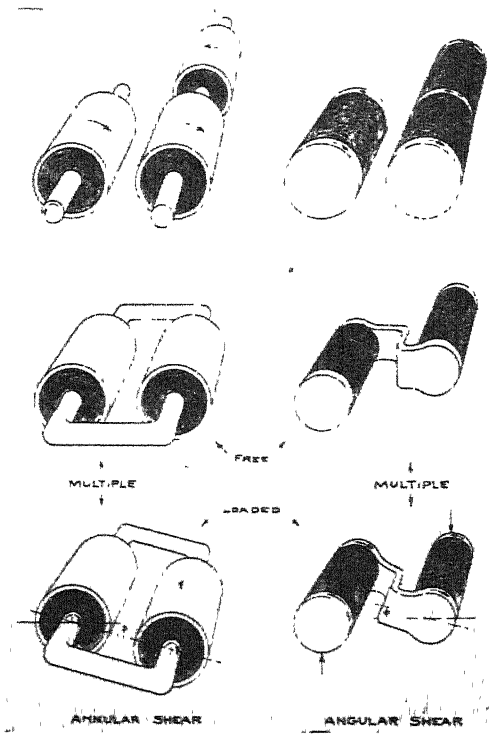
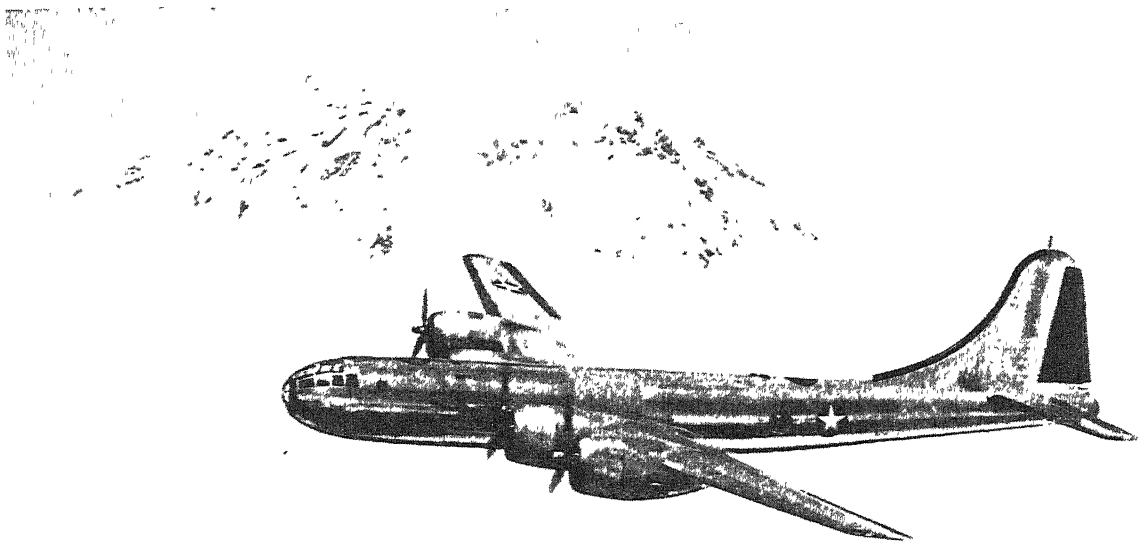


Figure 3: Right: Some compound torsional mountings





Illustrations courtesy Boeing Aircraft Company

America's mightiest warbird, the B-29 Superfortress

IN OTHER FIELDS

Conducted by The Staff

Battleship of the Air

The Superfortress (B-29) is Far More than the Outstanding Aerial Bomber so Far Produced; It is a Harbinger of Better Things to Come. Good Visibility, Pressurized Cabin, and Comfortization are Some of the Features that the Aviation Industry May Well Study

THE SUPERFORTRESS, the B-29 which the AAF has used to such good advantage in the Pacific theater, is so huge, so complex, that its detailed description would require a fair sized book, just as its design required a whole corps of engineers and draftsmen. But there are a few points of special significance that can be described here —points of not only military significance but of importance to the future of civil aviation.

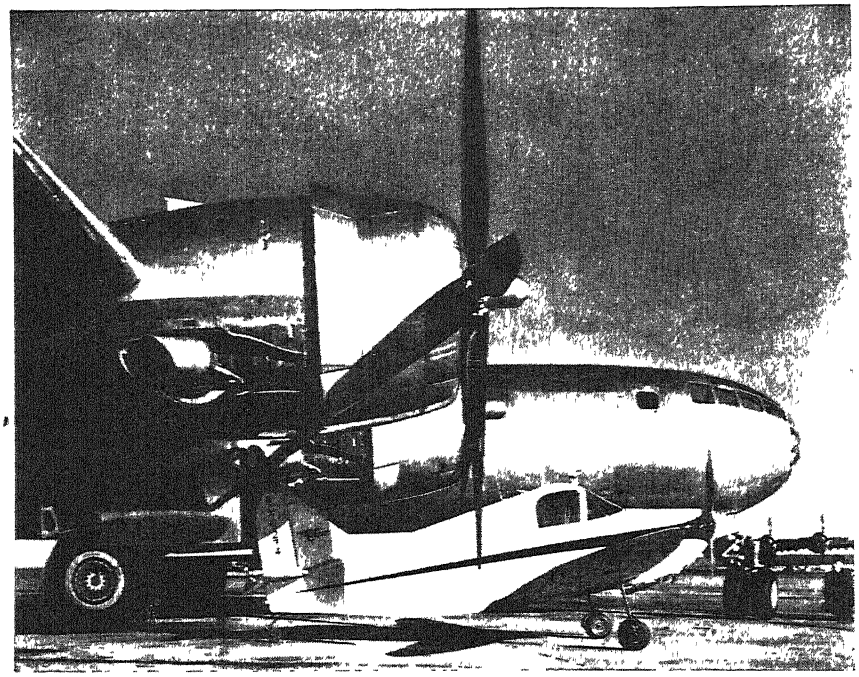
Although its performance is still secret, it is known that the B-29 has a greater range, flies faster, and carries a larger bomb load than any other bomber in the world. Thus the Superfortress becomes a new strategic weapon of such importance that these bombers will come under the centralized control of the Joint Chiefs of Staff, with a single commander, and will be ready to act in any theater of war.

It has been customary for many years to refer to bombers as battleships of the air, in the sense that a battleship is a vessel which can defend itself against anything afloat. It is perhaps only the Boeing Superfortress which really deserves to be called a battleship of the air: It is so robust, so armed and armored that it can defend itself against all comers—in particular against the best single-seater fighters. The B-29 is armed with .50-caliber machine guns, and 20mm cannon mounted in power turrets, with gun-sight blisters on the side of the fuselage. The vision for fighting is as good as the vision for piloting, and even the tail gunners have a roomy cabin and perfect vision in three directions.

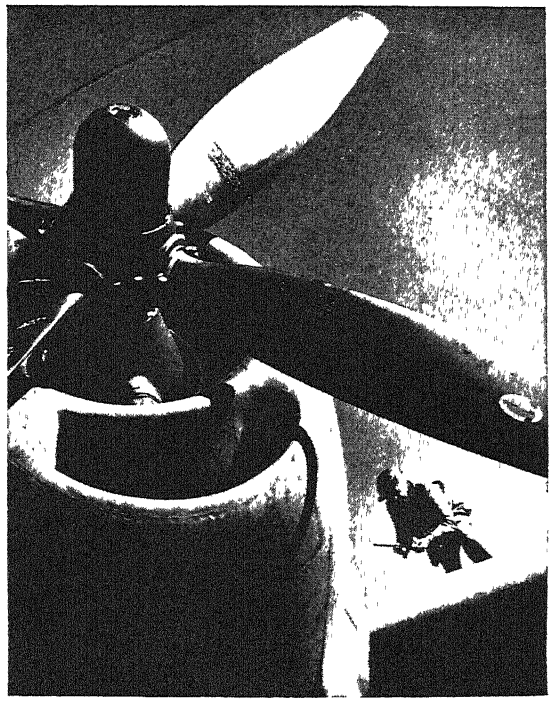
Many lessons can be learned from the Superfortress. The B-29 derives from the B-17 and its designers had a wealth of knowledge and experience to help them, yet the preliminary design was begun in 1936, some eight years ago. This means that the development of large military aircraft is a lengthy process, and that if, in the post-war period, our production is limited drastically, there should be no decrease in research, experimentation, and effort to evolve new designs.

Although the B-29 is a new ship, its similarity to the B-17 is so great as to point the moral that military aircraft design should be evolutionary rather than revolutionary. Still another thought, prompted by the accompanying picture of Wellwood E Beall, (Boeing vice president in charge of engineering, and responsible for the over-all direction of engineering), is that aircraft design rightly belongs to the hands of young men. Mr. Beall, a graduate of the Guggenheim School of Aeronautics

Wellwood E. Beall, the young engineer mainly responsible for the development of the new Superfortress



Above: The huge bulk of the Superfortress dwarfs the single-engined Culver by its side. The wing span of the B-29 is in excess of 141 feet and its extreme height is over 27 feet. Stability of the craft is remarkable



Right: Size of this four-bladed propeller of the B-29 can be gaged by comparison with the man. Note the single air duct in the nose of the engine nacelle

of New York University, is only 37 years of age. He combines solid engineering brains with imagination and executive ability.

The B-29 is enormous (the single-engined Culver is dwarfed in one of the photographs) and its dimensions are far greater than those of the Flying Fortress The B-29's wing span is more than 141 feet, its length is 100 feet, and it has an overall height of 27 feet, 9 inches. The Flying Fortress had a span of 103 feet, a length of 74 feet, 9 inches, and a height of only 19 feet.

REMARKABLE STABILITY—Aerodynamic novelties cannot be too great a part of the picture and the B-29 therefore has a very close resemblance to the B-17. It is cleaner, however, and has a longer cylindrical fuselage with the nose projecting far ahead of the wing. The characteristic Boeing large vertical fin and extensible flap are present, and the landing gear is so completely retracted that no sign of it is visible when in flight. The stability of the new craft is remarkable. By virtue of previous flight experience with the Flying Fortress, the Superfortress, in spite of the huge size of its control surfaces, has direct control which means remarkable refinement in balancing of the aerodynamic loads involved. The tricycle landing gear has been adopted, with two wheels on each of the three components of the landing gear.

The B-29, even if it did not produce startling aerodynamical novelties, had claims to great progress in size, performance, and construction, the overcoming of production difficulties, and freedom from bugs and development accidents.

But there is another aspect of the design which is equally noteworthy; that is, the greater comfortization of the aircraft. The day when the comfort of the crew in military aircraft could be disregarded has long gone by. Since the ship operates over great ranges, its design had to be such as to reduce crew fatigue and irritations to a minimum. First of all, heating and sound proofing are adequate, and the cabin is so supercharged that the B-29 can be operated at 40,000 feet without the use of oxygen masks or other annoyances. The bugaboo that prevented pressurization of military aircraft was the danger of "explosive decompression" if a shell should pierce the cabin. In early tests of the Superfortress, a side-gunner's blister blew out, but the crew members reached for their oxygen masks and no one suffered.

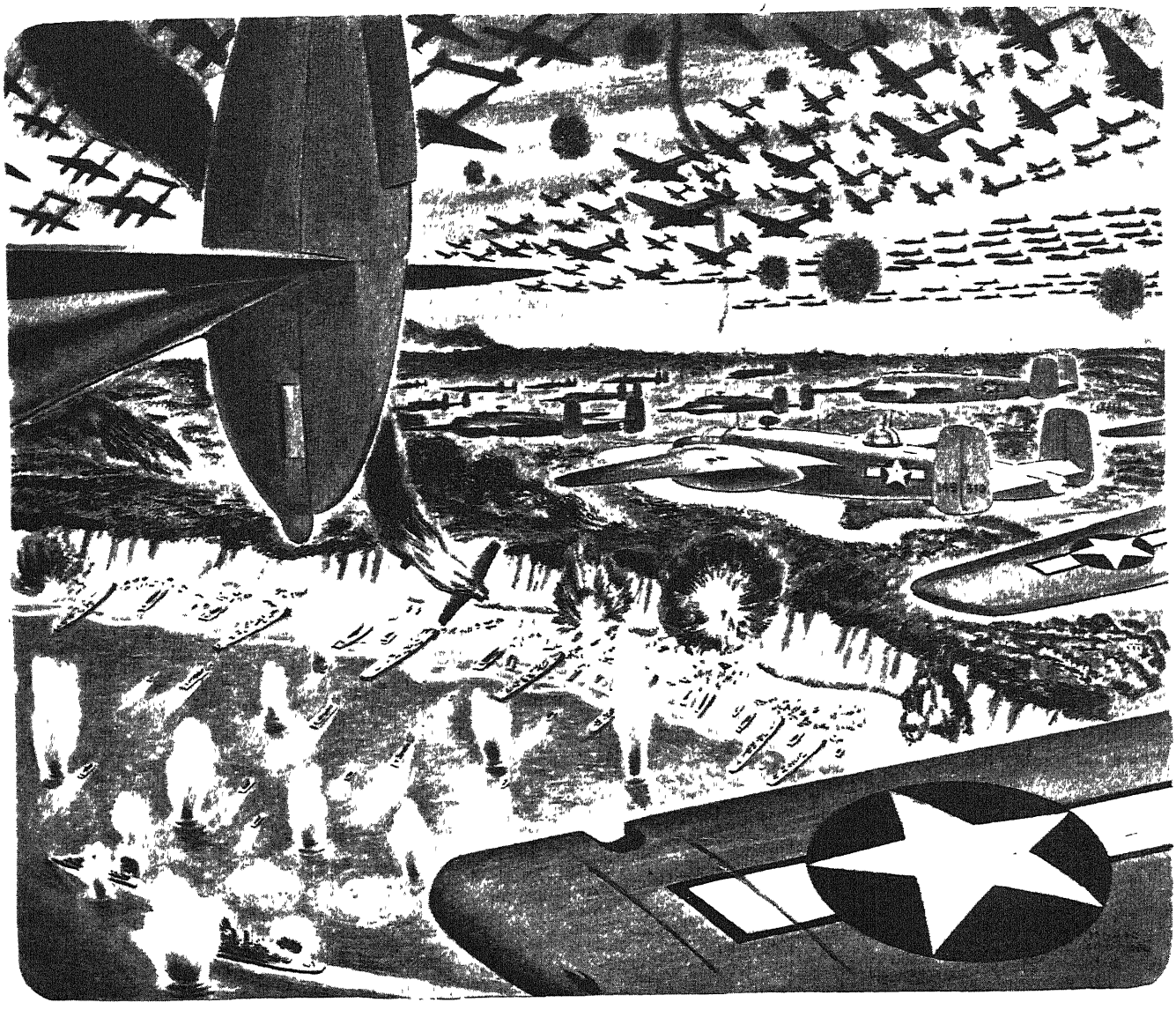
While the pilot and co-pilot of the B-29 occupy conventional positions, the complexity of the instrument board has disappeared. Pilots have just a few dials in front of them and the flight engineer back of them takes care of other instruments. Another physical and moral help lies in the fact that the bombardier is in the same cabin, on only a slightly lower level, and all four men can talk comfortably to one another in the soundproofed compartment There are eleven men in the crew in all and all of them are comfortable, thanks to a small bunk room, chairs with sponge rubber pads, and so on. The navigator has a big desk and chart rack. All this makes a great difference on a long and dangerous assignment.

It used to be thought that there was a definite limit to the power of the aircraft power plant; and that, when the motor reached a certain size, the propeller could no longer absorb its power

Both of these views are wrong, as is habitual with defeatist engineering predictions. The 18-cylinder Wright Cyclone produces 2200 horsepower and, while its development has meant overcoming many difficulties, it is remarkably successful. Certainly even this huge and complex engine does *not* represent the final word in engine design.

In rebuttal of the second of the two bad predictions named above, engineers have found it perfectly possible to design propellers capable of absorbing the power, and of maintaining high efficiency. First of all, Hamilton-Standard (responsible for the propeller design) built a four-bladed airscrew, with the enormous diameter of 16 feet 7 inches. Then, to avoid too high a top speed (and the compressibility shocks which might occur), they geared down the propeller to only 35/100 of the revolutions per minute of the engine. Then they used the NACA laminar-flow airfoil as a further safeguard against the effects of compressibility. Construction is of the conventional aluminum alloy type. Another interesting wrinkle in the powerplant design lies in the large duct in the nacelle nose which eliminates a multiplicity of air inlets in the wings and helps in giving the plane streamlining. Two superchargers are employed with each engine and are enclosed.

All in all the American people can be proud of the B-29, of the high ranking



It takes a lot of gasoline

TO MAKE AN UMBRELLA FOR G. I. JOE

WHEN YOU know that just one single-seater fighter carries about 500 gallons of gasoline on take-off, you can well imagine what any large-scale operation requires. The figures run into millions—and every gallon must be top quality. Fighting gasoline is the "cream" of U.S. production, practically all of which contains Ethyl fluid.

When peace is won, most of this high-octane gasoline will be able to stay home . . . and ultimately post-war automobile, truck, bus and tractor engines will be designed to get more power from high quality gasoline.

We of Ethyl look forward to working with the engineers of the automotive, petroleum and aviation industry in the development of post-war engines and fuels. Many of our research workers in Detroit and San Bernardino are now engrossed in necessary war work. When the fighting is over they will once more be ready to serve industry in the improvement of peacetime transportation.

+ + +

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GASOLINE POWERS THE ATTACK—DON'T WASTE A DROP!

officers of the AAF who sponsored it, of the test pilots and engineers who designed it, of the manufacturers, foremen, and skilled artisans who built it. They will be equally proud of the especially selected pilots, bombardiers, flight engineers, and gunners who will carry it on its missions against the enemy.

While the Superfortress is of tremendous military importance at the moment, the experimental and research work that has gone into its design and construction have written at least the first page of a new chapter in commercial air travel. Of course, not much can be said about details of the comfortization previously mentioned, but the groundwork has been laid for high-altitude flight by huge passenger planes in the near future. The same is true of many other details of the B-29, but out of such efforts by the best aeronautical brains will come faster, safer, more comfortable air transportation for the general public, plus a sounder basis for the post-war aviation industry.—*A.K.*

✠ ✠ ✠

HELIUM OUTPUT

Far Greater, Cost Lower Than Ever Before

HELIUM for war use is being produced for less than two cents a cubic foot and at a rate ten times greater than the amount turned out by a single plant before the war, according to *Aviation News*.

The price of less than two cents compares with $2500 some 25 years ago. Five plants are now producing helium for anti-submarine blimps, barrage balloons, meteorological balloons, and other war uses. Production for the last six months of 1943 and the first two months of 1944 greatly exceeded production for the entire preceding 12 months.

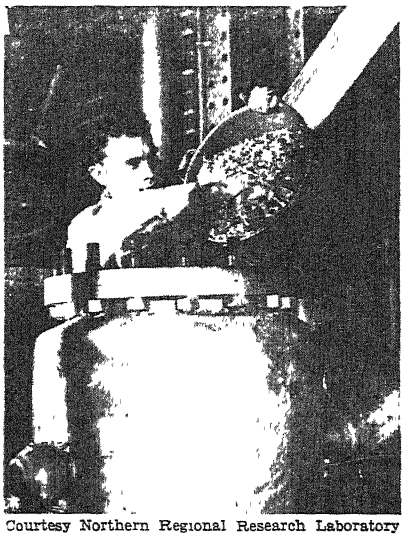
FARM-WASTE PLASTICS

Can be Processed in Normal Manner

NOREPLAST is the name of a series of new molding compounds which have been developed from farm waste in the United States Department of Agriculture's Northern Regional Research Laboratory at Peoria, Illinois. These compounds have been tested at several industrial plants and have successfully met the molding conditions normally used.

A company in West Virginia is now actively undertaking the commercialization of Noreplast. Another company in Ohio is considering Noreplast formulation for the post-war manufacture of toys.

A number of Noreplast formulations have been developed and rather thoroughly studied. Dr. O. E. May, Chief of the Bureau of Agricultural and Industrial Chemistry which operates the Peoria Laboratory, states that one of the significant things about this new plastic is that it can be made with one half the phenol-formaldehyde resin—a critical war material—commonly required in the manufacture of this type of plastic. All formulas contain 50 percent or more ground agricultural residues, such as wheat straw, flax shives, cornstalks, peanut shells, and so on, and some are mixtures of these. The formulas differ specifically in the amount of phenol-formaldehyde resin, either liquid or dry form, and in the percent of a special plasticizer designed specifically to produce rapid flow during the molding operation. The percent phenol-formaldehyde resin varies from



Courtesy Northern Regional Research Laboratory

Cornstalks being placed in a digester as first step in plastic making

47 to 25 percent, the plasticizer from zero to 15 percent.

Any of these Noreplast formulas will mold in the regular commercial moldings cycle and will produce articles having strength and finish characteristics approximately equal to general-purpose phenolic resins containing approximately 50 percent phenol-formaldehyde and 50 percent wood flour.

Water resistance in military articles is of considerable importance. Military specifications which Noreplast might serve have been set up on the basis of general-purpose phenolics. It has been found that as the percent of phenol-formaldehyde is decreased in Noreplast formulation from 47 percent to 25 percent the water resistance decreases. Noreplast with 47 percent phenol-formaldehyde content will meet military requirements, and 35 percent is satisfactory for some things. Requirements for strength and finish are met with a content of 28 percent but the water resistance is too low.

To prepare Noreplast, finely-ground agricultural residue is mixed with the dry or liquid phenolic resin, the powdered plasticizer, catalyst, lubricant, and coloring agents in a dough mixer or other machine capable of producing a uniform mixture. The mixture is then rolled between heated differential rolls to obtain the desired characteristics of density, flow, and setting time. The rolled sheets are then ground and screened to produce the molding compound ready for use. In experimental molding tests to ascertain the molding speed of the new plastic, it took about 2½ minutes to mold a pencil tray, pin tray, or a cup, about 23 seconds for a bottle cap; 2 1/3 minutes for a safety razor; and 3 to 4 minutes for the distributor head for an automobile ignition system.

The natural color of the molded product ranges from light brown to black, but products ranging from ivory or very light tan through light blues, greens, reds, browns, blacks, or mixtures of these colors can be made by the use of appropriate dyes and pigments. Flax shives, wheat straw, cornstalks, tobacco stalks, tobacco stems, peanut shells, and soybean hulls are the agricultural residues which have been compounded and examined. The particular residue to be used depends upon which one is the most economically available to the producer.—*The Chemurgic Digest.*

CONTINUOUS HEAT TREATMENT

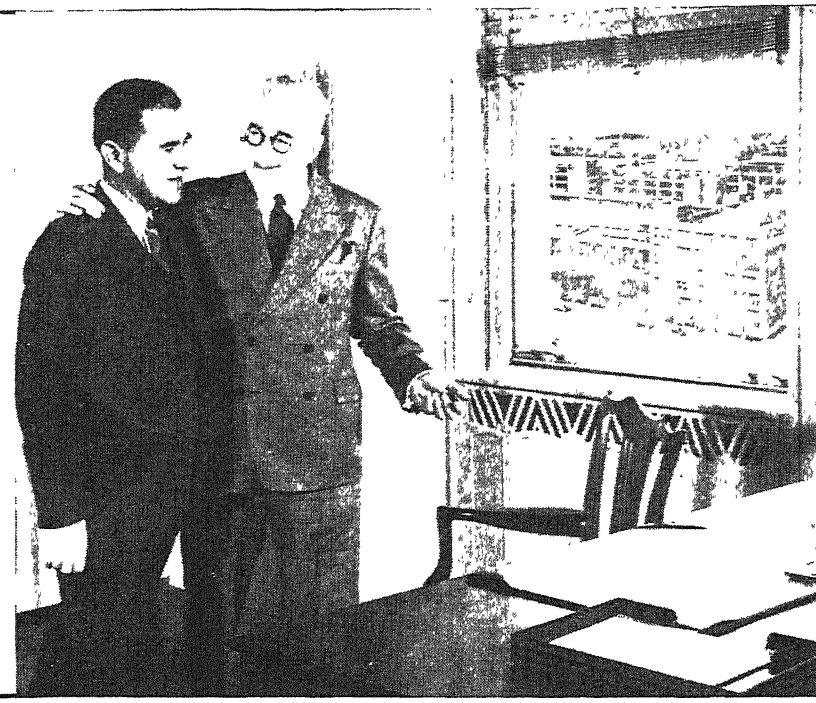
Made Possible by Use of High-Frequency Energy

THE FIRST production-line process of high-speed continuous heat treating, using Megatherm high-frequency energy, has been established by the Industrial Electronics Division, Federal Telephone and Radio Corporation. The application is to finished bearing pins, each 2½ inches long by ½ inch in diameter, case hardened to a depth of .025 inch as they are fed automatically through a glass tube and water quenched as they leave the heating coil at the rate of 75 bearing pins per minute.

High-frequency induction heating is the only known process capable of this performance. Employing five-megacycle energy, the surface of each part treated is heated above its critical temperature in less than one second. Due to the high speed with which the heat is applied to the surface, there is insufficient time for it to penetrate into the core and, in consequence, only a thin surface layer experiences a change in physical state. This means that the

Production-line heat-treating set-up and, inset photomicrograph of hardened surface of a bearing pin

Want to join the management?



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central portion retains all its original toughness and strength.

The factory application of this process to continuous production-line surface hardening of bearing pins involves the following equipment: the hopper from which the unhardened parts are fed into the glass tube; the heating coil; the Megatherm induction units, a connection providing a continuous flow of water for quenching, and an ordinary work table carrying suitable containers for the finished and hardened product as ejected from the heating fixture.

The pins are finish ground prior to heat treating, and after the hardening process there is no scale or warpage This is due to high speed of the process, which makes possible the surface hardening of parts after finish grinding. By the elimination of much costly finishing, which heretofore has been required on hardened steel parts, immense savings are effected.

The coil used in this bearing pin application is a single layer approximately one inch long by ¾ of an inch in diameter. It consists of five turns of small copper tubing, and is a permanent fixture which does not experience wear or deterioration. The water-cooled coil is grounded and does not carry high voltage.

The bearing pin application is only one of a family which includes a wide range of shafts, bearings, round and flat surfaces, zones, spots, cam surfaces, gear teeth, lever ends, and other common machine tool parts. The method has been applied to pieces as small as ⅛ inch in diameter and to bearing surfaces up to six inches in diameter. All applications are characterized by high speed, the fact that a uniform thin surface layer of hardened material is obtained, and by freedom from distortion.

STEEL STIFFNESS

Shown to be Greater Than That of Cast Iron

A SIMPLE device for demonstrating the stiffness superiority of steel over cast iron is shown in the accompanying illustrations.

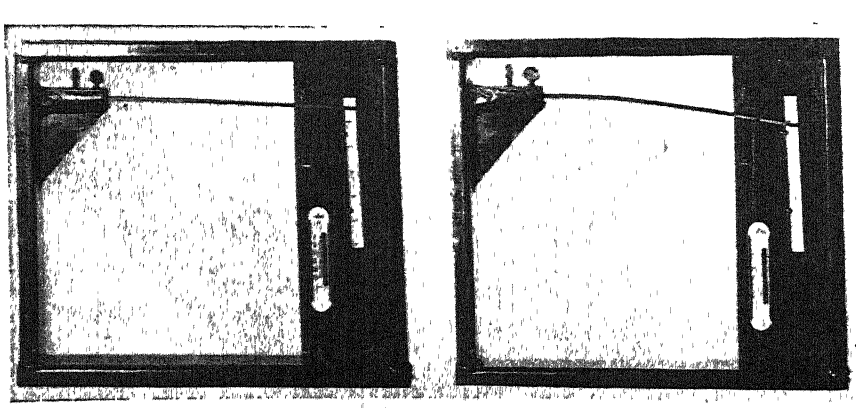
The testing unit was devised by C. W. Lytton, welding engineer of The Lincoln Electric Company. It consists of a square-shaped jig made of 2 by ¾ by 5/32-inch channels welded at the joints to form a 15½ by 13½-inch structure.

In demonstrating, two bars of equal size are used, one of steel and the other of cast iron. The first illustration shows the jig with a 12-inch steel bar, ½-inch wide by ⅛-inch thick, with one end inserted 1½ inches in a clamping support. A load of 2½ pounds has been applied through a rod attached to a small scale, the other end of the rod being attached to the steel bar exactly 9¾ inches from the fixed support.

Deflection of the steel rod under this load is 15/32-inch, as shown by the rule fastened at the right of the jig

The second illustration shows the results of a similar test using a cast iron bar of the same size with a 2½ pound load applied at the same point Here, the deflection measures 1 5/32 inches as shown on the rule, thus proving that the steel bar is 2.44 times as stiff as cast iron from the standpoint of deflection.

The results shown by this simple testing jig support laboratory tests of a similar nature which prove that steel is not only stiffer than cast iron but is also more resistant to fatigue, shock, and impact and is extremely ductile, thus fulfilling many design requirements.



A jig for demonstrating stiffness of steel (left) and cast iron (right)

TORQUEMETER

Extends Bomber Range, Has Other Applications

A "MAGNETIC TAILWIND" that will enable American bombers to reach targets 100 miles or more beyond their present range has been developed at the Westinghouse Research Laboratories The "tailwind" is a new magnetic-coupled torquemeter which makes it possible for a bomber pilot to determine the power output of his engines 10 to 15 times more accurately than with the method now commonly used. With this precise information, it is easy to adjust the engines to achieve maximum fuel economy, squeezing 5 to 10 percent more miles out of each gallon of high-octane gasoline.

The torquemeter conveys its information to the pilot by measuring the "twist" in the hollow steel shaft connecting a bomber engine to its propeller. The amount of twist—it may be only a few thousandths of an inch for a distance of several inches along the shaft—is an accurate measure of the driving force delivered to the propeller by the engine.

Vital part of the torquemeter is a stationary metal sleeve and coil assembly

The torquemeter is sensitive enough to measure the degree of twist exerted in a steel shaft by the hands

which encircles the propeller shaft. Projecting from rings on the propeller shaft are two sets of gear-like teeth whose faces are a few thousandths of an inch apart. As the propeller shaft twists under load, the relationship between these teeth changes. Invisible magnetic "fingers" extending across the gap between the metal sleeve and the shaft detect this change and report it electrically to the dial on the instrument on the board. The torquemeter enables the pilot to figure an engine's horsepower within 1 or 2 percent. With this knowledge he can adjust each engine's throttle, fuel-air ratio, and propeller pitch so all engines are delivering power at the same rate and at peak economy.

Other magnetic torquemeters are destined for use in laboratories where new types of aircraft, truck, and tank engines are being developed, and in naval laboratories, where engineers need accurate measurements of the power transmitted by a ship's propeller shaft, a set of reduction gears, or a whirling turbine.

ACID CARRIERS

Designed for Use on Air-Cargo Transports

ANOTHER knotty problem of air-cargo transportation has been solved with the use of synthetics. Dangerous corrosive acids such as hydrofluoric and a wide variety of solvents may now be transported in collapsible emergency containers as a result of further development by United States Rubber Company of synthetic products.

These containers are made in flexible disk form and measure 56 inches in diameter. They are assembled in two parts in sheet form. One is a light cotton fabric which is treated with vinylite. The other is coated with synthetic rubber. They are held together with small eyelets spaced about three inches apart which are stapled into the material. A light-weight cord is drawn through the eyelets. The completed article is then ready to be placed around either a glass or metal container and drawn tight, much as a tobacco

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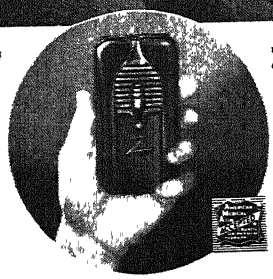

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pouch, to insure against spillage on any part of the plane.

The need for this article was found when Army aircraft engineers found that spillage of acid resulting from accidental breakage while in transit was seeping into the frames of planes which carried this corrosive cargo and doing untold damage to the fuselage. This method of shipping has completely eliminated this hazard.

Should breakage occur or should the caps of the containers become loosened owing to vibration, the acids now spill into the emergency wrapping. A flexible hose is inserted into a rubber disk which is placed into the top of the container before the draw strings are tightened The acid fumes are carried off through this tube, thereby completely dispelling any possibility of damage from fumes or liquid

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Made Accurately by

New Process

A SIMPLE and economical method of condensing and preserving vital records for an indefinite period is announced by Microcopy Corporation in the Microcopy Translite Hi-Reduction process. This is the application of microfilming to engineering drawings, as well as any other valuable record, document, drawing, map, or similar material kept in industrial manufacturing plant files. Because of the high-fidelity translite feature, it is particularly adaptable to engineering drawings, in pencil on transparent paper.

Microcopy, being a photographic record, is a faithful copy of the material microfilmed. The negative can be used to make copies on other pieces of film or to enlarge and make copies of the original in any size desired, whether actual, larger, or smaller. These copies may be made on tracing paper, cloth or film. As many film duplicates as desired may be made. Thus, duplicates made may be transmitted to branches, service depots, and other points.

For reading Microcopy, a Microcopy Multiple-Magnification Viewer is supplied in various models. This Viewer, operated on a motion picture film projector principle, is operated from a control panel. It facilitates finding locations on films by permitting enlargements to be made on the screen, as well as permitting any portion of the frame to be centralized within the frame for easier reading.

Microfilm image projected on screen of multiple-magnification viewer

SCIENCE EDUCATION

Needed to Meet the

Coming "Automatic Age"

AGGRESSIVE methods for capitalizing the immense "stockpile" of scientific knowledge built up in accelerated wartime research must include a broad educational program directed to the millions of average Americans who will want and use the improved products of the future, says Ernest R. Breech, president of Bendix Aviation Corporation.

"If industry is to maintain its status, re-established in this war, as the main driving force in American life, it must take the lead in coordinating science with mass education," he declares.

Stepped-up product development and amazing progress in mass production methods to meet war's unprecedented requirements for scientific devices, he points out, has brought the world 10 to 20 years closer to an ultimate "automatic age," destined to "remove drudgery, brute force, and awkwardness from the every-day lives of millions."

"Grappling with the realities of a scientific war for survival," Breech points out, "a large segment of Americans—including millions of American men and women on the battlefront and home production front—have speedily acquired a close-up practical education in basic and even advanced sciences that were little more than words to them a few years ago.

"In many cases, particularly in the armed forces, their intensive streamlined training has given them a more complete and workable practical scientific education than the average college graduate possessed 10 years ago. For they have learned to produce and master the efficient use of equipment which represents the highest peaks of development in electronics, hydraulics, electromechanics, aeronautics, the mechanical arts, chemistry, medicine, and physics

"Their rediscovered faith in scientific progress and the immense stockpile of personal ingenuity and practical knowledge they have built up the hard way in this war constitutes one of the nation's most valuable assets in translating wartime technical advances into terms of the common good.

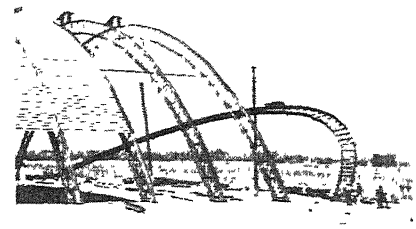
"But we must plan now to use and expand this tremendous educational force to develop a buying public keenly aware of the new opportunities that will be open," he concludes.

PORTABLE HANGAR

Assembled from Steel

Arches and Panels

SIMPLICITY of erection and saving of critical materials are among the advantages claimed for a new portable steel hangar building designed and manufactured by The American Rolling Mill Company. It is reported to be capable of carrying a higher load per pound of steel than any other current designs.



Up goes a hangar arch

Two sizes of hangar have been built to date, one with an inside width at the base of 152 feet and a height of 36 feet, 7 inches; the other with a width of 192 feet and a height of 48 feet. The length may be any multiple of 17½ feet.

The arches, assembled at ground level, are made up of pressed metal units bolted together into segments that are identical and interchangeable. Space between the arches is covered with standard Steelox panels. These span from arch to arch, serving both as purlins and roofing. They are bolted to the top chord of the arches. These panels are the same as have been in use for frameless steel building construction. The ends of the hangar, including the doors, are built of Steelox panels. A new type of multiple door section is supported on a single bottom rail

ENGINES OF WAR

Provide Power For Global

Fighting on Land, Sea, and In The Air

NIGHT and day, America's No. 1 mechanical hero, the internal combustion engine, is blasting away at the enemy's stronghold from land, sea, and air in a mighty outburst of power.

A steady toiler in peace and a raging force in war, the internal combustion engine has taken on many new roles in this global conflict, powering a variety of craft from Ducks and PT boats, to jeeps and 400-mile-an-hour fighter planes.

Engines by the carload have rolled from automotive assembly lines since the war began. Ranging from small stationary engines to the huge power plants of super-bombers and super-fighters, they are providing America's fighting men with unexcelled performance on land, on sea, and in the air.

Horsepower potential of these engines, not available because of so many weapons still on the secret list, would be almost unbelievable. However, the 220,000 aircraft engines alone, that have been delivered by the automotive industry, represent the astronomical total of 297,150,000 horsepower. This is equivalent to the combined generating capacity of 84 Boulder Dams and 56 Grand Coulee Dams. Or, it is

equal to nearly 30 horsepower for every man in the armed forces.

Automotive research and development in the Diesel type of internal combustion engine is mainly responsible for the startling fact that Diesel power now exceeds steam power in the United States Navy.

All the four major type landing craft, so prominent in current invasion dispatches, are powered by Diesels, 71 percent of which are produced by a single automotive company.

The powerful gasoline engines of the Navy's sensational PT boats are an exclusive product of another automotive firm—a development going back to the Detroit River speed-boat races.

Even the Army's reliable foot soldiers, the men of the infantry divisions, have 400,000 horsepower per division at their disposal. Representing an 11,000 percent increase over the 3200 horsepower of the World War I infantry division, the mobility of today's infantry points up the progress that has been made by automotive engineers since the end of World War I.

More than two and a quarter million military vehicles have been produced by the automotive industry since the present war began in 1939. The horsepower represented in these vehicles, combined with the automotive-produced engines for tanks and ships, planes and submarines, and the thousands of other wartime uses of the internal combustion engine, presents a staggering total. It adds authority to the recent statement of a high Army officer that "this is a war of motors."—*Automotive War Production.*

WATER REPELLANT

Fabric Designed on New Hypothesis

A NEW type of water-repellent cotton fabric, whose water-resisting properties are due largely to the unique construction of the cloth, has been developed by Dr. F. T. Peirce of the British Cotton Industry Research Association, at Shirley Institute, according to *Textile World.* Reports from England indicate that the Shirley method is being employed in the manufacture of fire hose, canvas, and raincoat fabrics, and recently some experiments have been carried out in this country on production of similar types of water-repellent fabrics.

"In his experiments," says *Textile World,* "Dr. Peirce worked on the hypothesis that if the cotton fibers in a fabrics were in such a condition that they could swell when moistened, they would, in contact with water, block up the interstices in the cloth, thereby making it water-repellent and water-resistant."

FIREPROOF UPHOLSTERY

Is Also Resistant to Oil and Gasoline

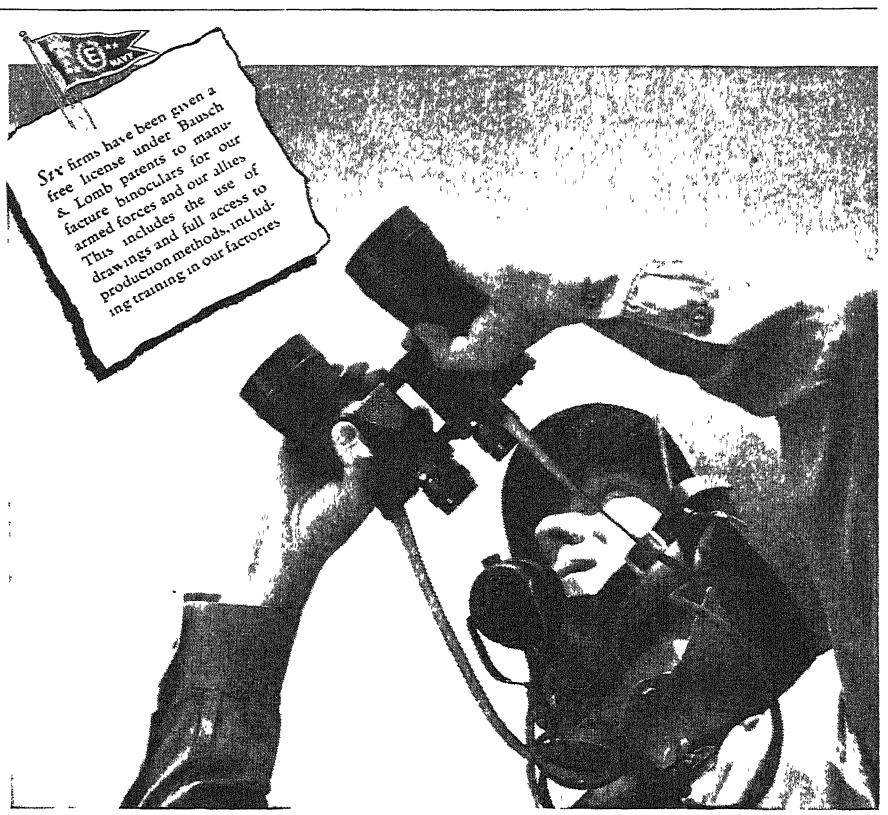
A NEW plastic fireproof upholstery has been ordered by the Navy as mandatory equipment for all combat ships, to provide added protection against fire. The upholstery covering, which will be used on furniture of all new Navy combat ships and old ships returning to service after repairs, is non-smoldering, gasoline and oil-resistant, and extremely durable under wide temperature ranges. It is also being used as turret lining and seat covering in both bomber and fighter planes

The plastic upholstery will provide for the first time, in peace years, a fireproof upholstery for use in night clubs, theaters, civilian airplanes, passenger ships, buses and trucks, and so on.

Before the fireproof upholstery was submitted to the Bureau of Ships, the United States Rubber Company submitted the material to many rigid tests. In the fire test the material was suspended for 12 seconds in the flame of a Bunsen gas burner. After removal, it burned less than two seconds.

To prove its resistance to high temperature, it was exposed for three hours at 180 degrees, Fahrenheit, without becoming soft and tacky. To prove its resistance to low temperature, it was subjected to a temperature of -40 degrees, Fahrenheit, without cracking when sharply creased. After exposure to oil for an hour, it showed no permeation of the fluid or other ill effect. After exposure to gasoline for a minute, it showed no permeation of the fluid or other ill effect.

Because fire and smoke caused loss of combat ships, the Navy asked United States Rubber Company during the fall of 1941 to develop a fireproof covering for berths that would eliminate the haz-



Experience Shared . . . Production Multiplied

When war came to this nation, even the greatly expanded facilities of Bausch & Lomb could not meet the urgent demands for binoculars as well as the range finders and other military instruments which only this company was equipped to produce. There was a tremendously increased need, too, for optical instruments of the utmost precision for industrial research and control . . . that our fighting men might have fighting tools second to none.

Faced with this situation, Bausch & Lomb at once increased its own binocular production more than twelve hundred per cent and multiplied its effectiveness by making its specifications and production experience available to six other manufacturers.

In addition, the Bausch & Lomb glass plant makes and supplies the fine optical glass which goes into lenses and prisms not only of the binoculars this company manufactures, but into others as well.

Thus, through the expansion of its glass plant and the sharing of its knowledge and experience in binocular manufacture, Bausch & Lomb is making possible an uninterrupted supply of these optical instruments for America's Armed Forces.

BAUSCH & LOMB
OPTICAL CO., ROCHESTER, N Y

ESTABLISHED 1853

Makers of Optical Glass and a Complete Line of Optical Instruments for Military Use, Education, Research, Industry and Eyesight Correction and Conservation

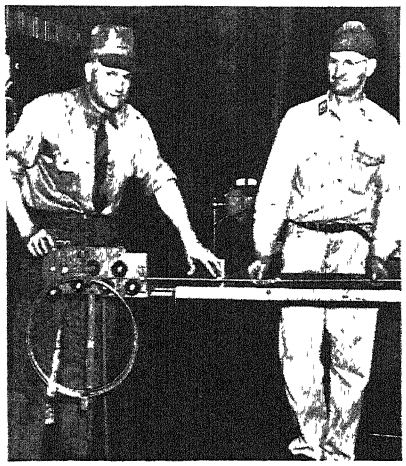
ard of burning or smoldering mattresses and bed covers.

Through the use of synthetic resins, laboratory technicians in one of the company's plants perfected a fireproof compound to be used as a coating on a fireproof base fabric—developing for the first time a coated fabric that was fireproof as well as waterproof. Later the material was improved to include resistance to oil, gasoline, salt water, and perspiration and to provide durability over wide temperature ranges.

TUBING STRAIGHTENER

Saves Valuable Man-Hours in Industry

A DEVICE which speeds up a time-consuming operation—that of straightening rolled steel tubing—has been devised by two employees at one of the plants of The Cooper-Bessemer Corporation. Typical of many practical ideas that have been conceived by workmen and put into use to increase efficiency in various industries, the tube straightener is one of the simplest of labor-saving tools. Made of a few odds and ends of metal and a series of five rollers, the device eliminates former hand-straightening operations which



Worker-devised tubing straightener

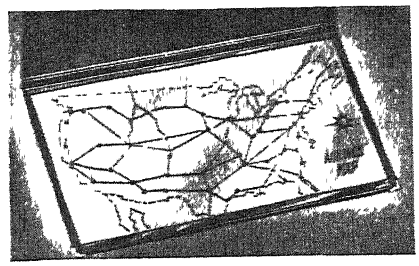
consumed valuable man-hours that can now be utilized in more productive work.

The tubing, of 1/4- and 5/16-inch diameter, is received in large coils and previously had to be unwound as needed, straightened with a paddle, then bent and formed to fit a specific connection. With the device shown in the accompanying illustration, the coil is simply positioned over a bracket at the side of the contrivance, the loose end is threaded through the rollers, and the tubing is straightened by pulling it out along a horizontal tray where it is measured and cut off to the required length.

FLUORESCENT ENVELOPES

Make Contents Visible Under "Black Light"

FLUORESCENT plastic envelopes are making night map reading possible aboard Allied planes, ships, and small boats



The envelope illuminates the chart

without the need of blacked-out quarters in the navigator's compartment

"Plastacele" cellulose acetate plastic incorporating a fluorescent pigment emits a minimum glow sufficient to make descriptive material covered by the envelope visible under the "black light" of near ultra-violet rays. Visibility of materials enclosed by the envelopes is also good under ordinary white light or in daylight.

Already at least one commercial airline is planning to make use of this interesting war-time development in its post-war operations.

HEAVY-DUTY OILS

Post-War Motorists Will Benefit from Technical Progress

HEAVY-DUTY lubricating oils satisfactory for use in internal combustion engines under extremes of heat, cold, and service have been developed for the United States Army by the automotive and petroleum industries, according to Captain W. B. Bassett, Office, Chief of Ordnance, Technical Division.

Describing the development before the recent SAE National Diesel-Fuels and Lubricants Meeting, Captain Bassett said that the oils, containing complex compounds assuring stability under heat, low pour points in cold weather, resistance to corrosion, and adequate detergency, have been standardized for use in the Army's Diesel and gasoline engines. Some of the oils were ready for public use just before the war, he added, but shortages and military requirements have restricted their use until post-war.

Typical of the performance of the oils in service, Captain Bassett explained, are results of a 5000-mile test run with cargo trucks. Operated without oil change and with crankcase temperatures held at 280 degrees, Fahrenheit, the engines were said to have been found in unusually good condition, with piston rings free, no deposits evident, no sludge accumulated.

UNIT REFRIGERATION

Saves Weight and Space On Board Ship

NEARLY 1600 square feet of vital cargo area and more than 16,000 man-hours of installation time will be saved on 133 of the nation's new Victory ships by a compact new packaged refrigeration plant, a development of the York Corporation engineering laboratories in collaboration with naval architects.

By conserving weight, space, and vital material through the design of the new unit, ample refrigerated stores of fresh foods will be made available even on extended voyages. Outstanding feature of the packaged plants is the combination of twin refrigeration compressors, receivers, condensers, and all refrigerator auxiliaries which, by means of cross connections, can be operated separately on both high and low temperature rooms In emergencies, either compressor can be connected to carry both high and low temperatures simultaneously.

Refrigerant receivers for the plants form an integral structural part of the base, thus increasing the rigidity of framework at the minimum of weight. Built in the form of a rectangle, all piping and valves are located for easy accessibility to all parts In addition to their application for ship stores refrigeration on the Victory ships, York is now building similar packaged units for other type vessels

With the exception of piping connections to cooling coils and water supply, the new unitary apparatus is ready to use when shipped, saving valuable assembly time.

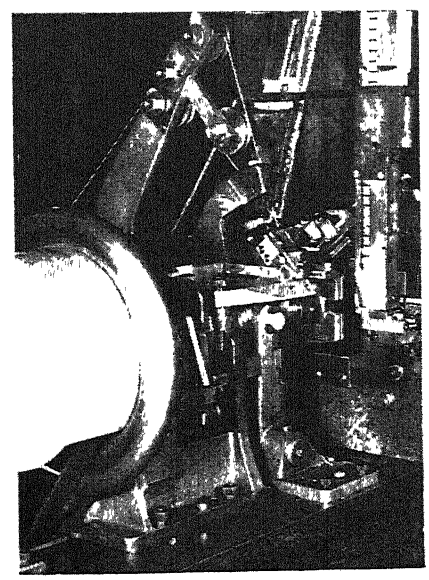
COIL WINDER

Delays First Turn to Meet Specifications

THE PRINCIPLE of the "delayed buck" of the gridiron is helping to produce generator armature coils. As the husky fullback is delayed a second before crashing into the line, so a strand of wire is delayed before it is sent spinning to form a coil.

Engineers of the Electric Auto-Lite Company developed the machine for winding the armature coils of a popular type of generator that has two windings—one of four turns and another of three turns of wire. However, the two windings must be made together so that they can be fastened into one unit before being inserted in the armature.

At first the coils were wound from two stands of wire in a rectangular form, after which the operator cut one turn away—a process which not only



Delayed rotation solves coil problem

delayed production but also necessitated the waste of about 12 inches of wire.

After many experiments a machine design was developed which delayed the rotation of the second part of the winding form until the first wire had made one complete turn.

After this turn had been wound, the three additional turns are wound with both wires to complete the coil. This gave four turns on one coil and three turns of the other coil as specified.

CERAMIC DEFECTS

Revealed by Penetrating Eye of the X-Ray

SOME interesting developments on the application of x-rays to ceramic materials and products have been disclosed as the result of co-operation between 20 ceramic companies and North American Philips Company, Inc., in the investigation of problems involving refractories, glass, insulators, crucibles, and chinaware.

Radiographs show that plate glass and lead glass—which look the same to the naked eye—are radically different when photographed by x-rays. Since lead greatly affects ray absorption, it is possible to detect small differences in lead content. Radiographs of fire brick and refractory furnace orifice rings reveal hidden defects, not visible on the exterior. Bread plates which were radiographed before and after glazing showed the uneven distribution of the glaze after firing. Glaze mixtures usually contain compounds having high atomic weights (high ray absorption) and, though applied in thin layers, differences in thickness show up remarkably well.

MATERIAL HANDLING

Adds to Cost but Not to Value

MATERIAL handling is the greatest single item of labor cost in most industries, according to Randolph W. Mallick, Section Engineer of Westinghouse. "In the United States alone it constitutes about 22 percent of labor costs and represents approximately a $4,000,000,000 payroll annually.

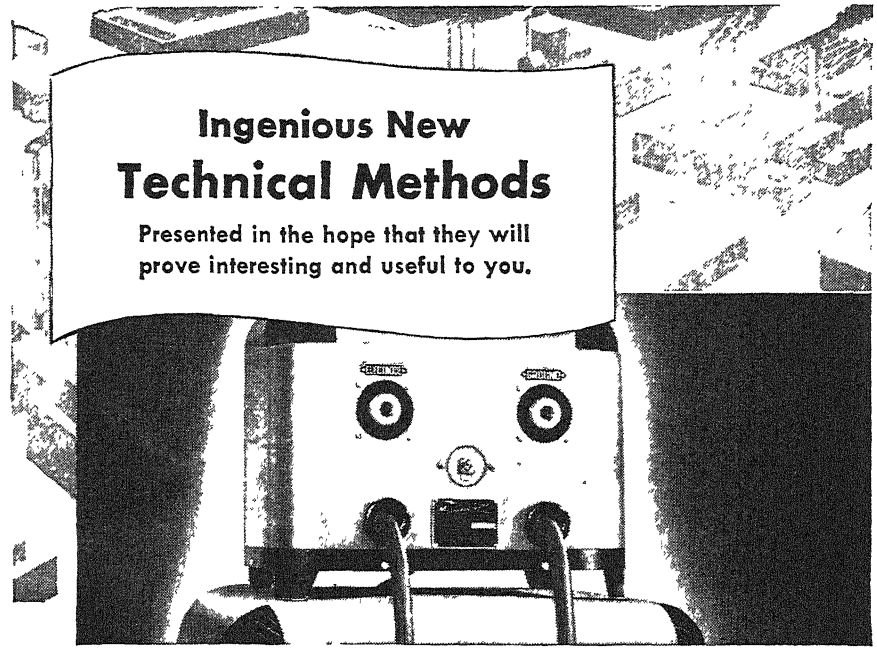
"Material handling is one very important operation in industry which adds only to the cost and nothing to the sales value of the product. The ultimate consumer is interested only in the quality and usability of the product, and in most instances these things suffer when the product is handled unnecessarily and excessively. In handling, parts are often damaged, lost, misplaced, and require additional use of time and facilities.

"Intensive studies of effective work areas have proved that work areas within the range of a normal sweep of an operator's hands are the most effective for a given performance," Mr. Mallick continues. "Time lengthens the manufacturing cycle. The longer the manufacturing cycle the lower the total output in a given period. The lower the output, the higher the cost.

"We know that if material can be brought to an operator at a steady rate, to a predetermined position, and taken away from an operator at a constant rate, from a fixed discharge point, then the operator's effort will be used in the most effective manner. This is an ideal condition, and while it would not be the answer to every problem, much can be done by using this ideal condition as a nucleus around which to work. Just casually watch some person doing something in the course of his every-day work and mentally visualize how that simple operation could be improved. We must recognize the fact that persons are not normally conscious of doing things in the most effective manner. Habit has much to do with it.

"In many industries today we have such machines whose output is largely dependent upon the effectiveness of the operator. If the operator is burdened with material handling, then he is not producing to the best possible advantage, nor is the machine, which represents a capital investment, and possibly today, a critical part of our war effort. I have seen machines perform operations in fractions of a second while the material handling preparation required ten-fold that amount of time.

"Although we classify industries as continuous-flow, such as oil refineries, distilleries, certain foodstuff industries, and the like, and intermittent-manufacturing industries, such as most of the equipment and apparatus plants, we are prone to accept these classifications too definitely. It is possible and it should be a goal for all plant-layout and material-handling engineers to try to ap-



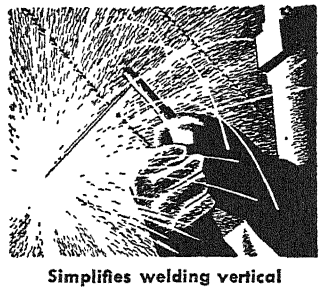
Revolutionary Hy-cycle Automatic Arc Provides Complete Control of Arc and Heat

At last, a development that automatically starts the arc before the welding electrode actually comes in contact with the work! Eliminating the "pecking" or "scratching" that so often creates tension and operator fatigue. Its many advantages contribute largely to saving time and labor because an operator can be trained in far less time than usual, and higher speeds can be obtained This hy-cycle automatic arc unit, called "Missing Link," permits the operator to weld with any welding rod, bare steel or alloy. Rods that could not be used before can be burned with ease—such as bare mild steel, dust coated, reverse polarity, aluminum, bronze, stainless steel, etc., AC or DC.

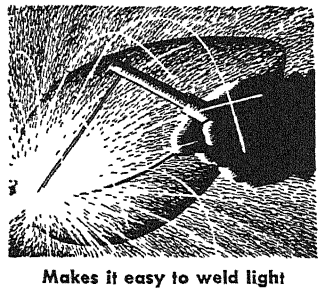
One of its most important advantages is welding light gauge. Light gauge requires low heat—making many jobs almost impossible for ordinary methods. Since the "Missing Link" starts automatically on as low as one ampere of heat, the welding of light gauge sheet can be done with surprising speed with no time out for "pecking" and "sticking."

You all know that our fighting men need the finest quality materials that we here at home can produce. That goes for Wrigley's Spearmint Gum, too. Although our stock pile of quality raw materials is getting lower and lower we are maintaining our standards of quality. Naturally, we are forced to limit production. So we are giving priority where it is needed most—and where you want us to—our fighting men and women overseas only. Because chewing gum is essential to them—they are getting all of our limited production of Wrigley's Spearmint Gum.

You can get complete information from Mid-States Equipment Company, 2429 S. Michigan Ave., Chicago 16, Ill.



Simplifies welding vertical and overhead



Makes it easy to weld light gauge work

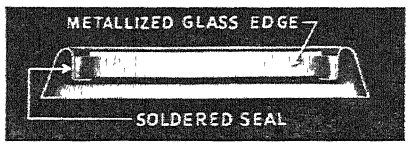
Y-133

ply the principle of continuous flow to as many operations in intermittent industries as possible," Mr. Mallick concludes. "Each time material is stopped in its cycle of process or is set down and picked up, we add to the cost of the product."

GLASS-TO-METAL

Soldering Made Possible By Metallizing

AN EXAMPLE of unusual uses for metallizing is to be found in American Meter Company's soldered seal index box for gas meters. This unit employs a Pyrex glass window which is soldered to its



Sprayed copper permits soldering

metal frame. Gas-tight, air-tight, shock-proof, and unharmed by repeated washing in the cleaning solutions used in meter repair work, this remarkable bond between two such dissimilar materials owes its permanence to metallizing.

Copper is first sprayed on the edges of the glass, providing a perfect surface for the solder which seals glass and metal frame together. In most applications of this type, the only preparation necessary is to heat the glass prior to metallizing. This method of preparing glass for metallizing is used for many other applications, including the sealing edges for double windows used in store refrigerators, and for reflective and masked surfaces on light bulbs—*Metco News.*

PUMPING WITH AIR

Gritty Liquids Can be Handled With Quickly Rigged Equipment

COMPRESSED air has been applied to actual lifting of water and other liquids from wells for better than half a century, but only in more recent years has engineering knowledge overcome a popular misconception regarding its utility and performance.

The most universal application is, of course, in the pumping of water or oil from wells.

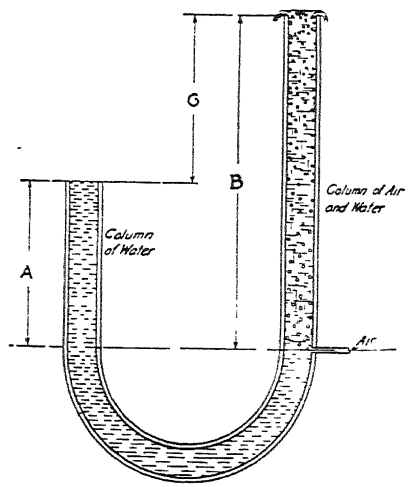
Consider an open well, or any body of water deep enough, regardless of its volume or the nature of its enclosure—a pond, lake, or river. In the water is fixed a vertical pipe for water and a pipe for compressed air. These pipes should be submerged for a certain depth proportionate to the lift when the pump is at work.

It is understandable that the water, being free to enter the lower end of the pipe, will rise to the same height inside the pipe as it stands outside the pipe. Now, if air is introduced under pressure through the air pipe into the base of the water pipe, the result will be an air lift pump. The question at once arises as to what will prevent the air from going down and thus discharging the water from the lower end of the water pipe rather than forcing the water up through the pipe?

The answer is this: The air operates as a pump to lift the water because the unbalanced hydrostatic pressure in the discharge pipe is from a mixed column of water and bubbles of air of lower specific gravity than the water outside the pipe or below the air entrance. Thus the flow is started as this modified water seeks a higher level, due to its lighter weight and the unmodified water is constantly being forced up by its own equalizing pressure into this lighter mixture. A continuous flow of compressed air into the discharge pipe creates a continuous pumping action. The amount of flow is dependent upon the amount and pressure of the compressed air introduced.

Advantages of the air lift include the ability to handle gritty liquids and acids without damage to pumping efficiency.

The principle of pumping with compressed air rather than with mechanical devices, has logical applications in many fields. Contractors who have air compressors also have air pumps. They could use the principle here described for emptying water-filled excavations or for filling supply reservoirs from adjacent streams and lakes. In the oil fields, the compressed air pump can be



How air lifts water

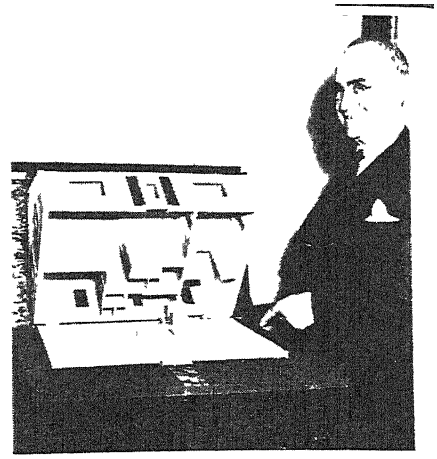
used to transfer impounded oil into storage, to repressure and pump out sluggish wells. An air lift pump can be rigged up quickly to "bail out" ships' holds or to fill tanks of ships operating in fresh water.

RADIANT HEATING

Demonstrated by Hinged Model

RADIANT heating, which some architects and engineers affirm will be one of the three or four revolutionary ideas to be accepted generally by the building industry after the war, already has achieved nearly a thousand recorded installations in this country, according to L. F. Rains, president of A. M. Byers Company, who have pioneered development of the system.

Radiant heating is considered to be particularly applicable to industrial and commercial structures, with special interest being demonstrated by architects and engineers concerned with factory, hospital, school, church, airport, and public building construction, Mr. Rains states.



Display shows heating pipes

To demonstrate in simple manner how the system functions, the company is equipping its staff of field service engineers with miniature displays like the one with which Mr. Rains is shown.

The display, hinged at the back, can be raised to reveal transparent flooring in which is embedded illuminated tubing. This tubing simulates the wrought iron pipe coils through which, in actual installations, hot water is circulated to convert the entire floor into a heat radiating surface.

WATER SOLUBLE

Cellulose Derivative Exhibits Useful Properties

SODIUM carboxy-methyl-cellulose, a cellulose derivative which is soluble in water, introduced by Hercules Powder Company, is undergoing experimental research to determine the suitability of the material in the manufacture of emulsions, paints, and textiles, and in the oil and other industries.

Now in small-scale production, the chemical is available in experimental quantities only. Properties of sodium carboxy-methyl-cellulose make it a stabilizer emulsifying agent.

"The material should be useful where hydrophilic colloids possessing marked suspending, thickening, stabilizing, and film-forming properties are required," the company says. "Some of its possible applications are to thicken textile printing pastes, to emulsify emulsion paints and lacquers, and to provide a protective colloid for oil-in-water emulsions.

"Its film-forming properties make it useful in coatings, particularly for greaseproof coatings. Other uses for the water soluble colloid are in the manufacture of boiler compounds, creaming latex, oil drilling muds, ceramics, can sealing compounds, anti-stick compounds, leather finishes and many other industries.

"Sodium carboxy-methyl-cellulose is supplied as a white, granular powder, odorless, tasteless, and readily soluble or dispersible in water. Very viscous, stable aqueous solutions can be ob-

[illegible] with aqueous solutions can be evaporated, leaving colorless, tough, transparent films which are unaffected by the common organic solvents, oils, fats, and greases. Some salts and acids react with sodium carboxy-methyl-cellulose films insoluble in water."

Tables and data have been prepared by the company showing viscosity, effects of salts and acids, compatibility with various materials, and physical, chemical and other properties.

MILDEW-KILLER

Is Non-Poisonous, Easy to Use

To KILL and prevent mildew is the aim of a new product, called Mil-du-rid, which is believed to be the first fungicide for home use. Hitherto, such fungicides have been for industrial or agricultural purposes and have contained poisonous ingredients unsuitable for household use. Its need and its performance have been amply demonstrated on military fabrics under field conditions in the tropics.

Mil-du-rid can be used safely anywhere in the home . . . on shoes, luggage, books, clothing, rugs, furniture, walls, floors, closets, basements. It can be wiped or sprayed on and will not harm anything water itself does not harm.

Laboratory research has perfected the formula which will kill and prevent the growth of mildew on all types of materials and textiles found in the average home. Mil-du-rid is a highly concentrated liquid which consumers can use either full strength or diluted with as much as 50 parts of water, depending on the specific use

SPEEDWAY EYES

Necessary for Safety On Post-War Highways

EYES of millions of American automobile drivers would be menaces on the proposed national system of speedways which would be designed for cruising speeds of not less than 75 miles an hour.

Although the visual qualifications of drivers in respect to high speeds are almost wholly neglected by automotive safety organizations, enough facts have come to light to show that eyes of drivers have an important bearing on safety, and that many drivers now are operating their cars at speeds beyond their visual qualifications, says the Better Vision Institute.

A series of studies on the relation of seeing distances to car speeds was made at Iowa State College, which led A. R. Lauer, associate professor of psychology, to conclude that unrestricted driver licenses should be given only to those having "at least 20/40 vision in both eyes, or 20/30 vision in one eye. When vision reaches 20/80 or 20/100 it may be best to limit the applicant to daylight driving or to speeds below 30 miles an hour." For eyes with natural acuity of less than 20/100, he recommends top speeds of under 25 miles an hour, saying that such recommended speeds will seem quite low, but they are calculated in accordance with the known facts of seeing and stopping distances. They actually represent the safe speeds for the classes of drivers concerned"

COLD TREATING

Develops Physical Changes in Metals

COLD treatment of metals—very cold—ranging from 80 to 130 degrees below zero, was described recently by G. B Berlien, Chief Metallurgist of the Lindberg Steel Treating Company, at a meeting of the American Society of Mechanical Engineers. In a paper entitled "Sub-Zero Refrigeration Applied to Tool Steels," Mr Berlien said in part:

"All of us who are working with metals that respond to heat treatment are aware of the fact that various cooling mediums, such as salt brine, water, oil, hot lead, and hot salt, are used to provide suitable rates of cooling for the type of steel being treated. Discussions of the use of these quenching mediums inferred that quenching would reach its ultimate in effect at room temperature or slightly above room temperature.

"Science is seldom satisfied with the ordinary concept of supposed truths and therefore investigators decided to find out whether there could be any further change in the structure of metals that were cooled far lower than room temperature. Early investigations were made using liquified gases, such as liquid air, liquid oxygen, and liquid nitrogen. Solidified carbon dioxide, or dry ice, also served to supply an intermediate temperature between room temperature and the temperature of the liquid gas.

"Several physical changes were noted in metals that had been quenched to very low temperatures. First, there was an increase in magnetic qualities. Also, a volume increase that was permanent at room temperature after such treatment was an important factor. Along with the above two changes, there oc-

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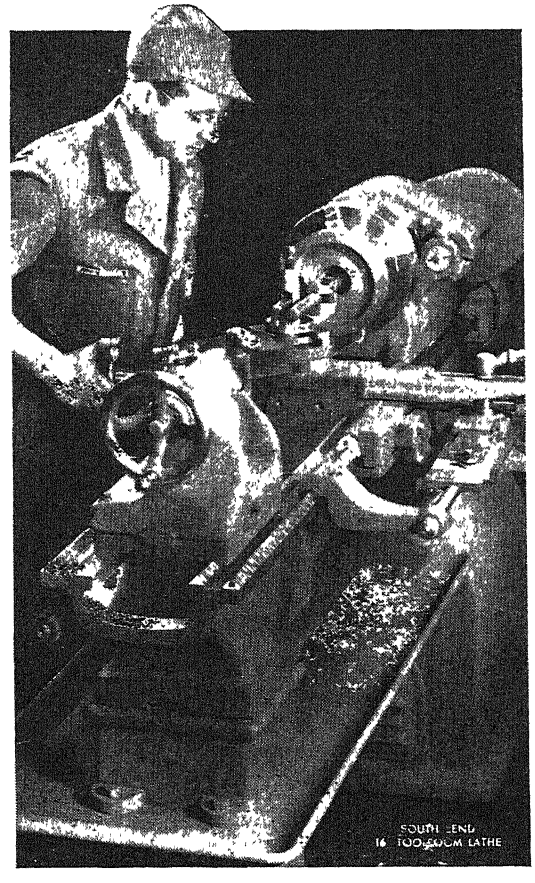

In every theater of war South Bend Lathes are holding to their pre-war traditions for dependable precision. In the mobile machine shops of our mechanized forces they duplicate factory tolerances on intricate parts needed for emergency repairs on essential equipment. On board many of the Navy's fighting ships, where high precision is an absolute requirement, they are also depended upon for the repair of mechanical equipment. In the repair bases of the Air Forces, they play an equally important part in keeping planes in service.

In all classes of war service these lathes are doing fine precision work—not only with the armed forces but also in industry where dependable accuracy is as vital as speed and versatility in meeting war's ever expanding production schedules.

When civilian production is resumed, South Bend precision will again prove as indispensable to peace-time industry as it is now for exacting war work.

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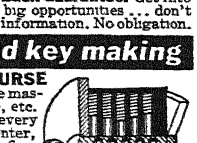

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curred an increase in hardness sufficient to detect with conventional hardness indicators, such as the Rockwell machine. The temperature required for these changes ranged from 80 degrees below zero, Fahrenheit, to 130 degrees below zero. The temperature requirements are governed by the alloy content of the material in much the same way as the hardening temperatures are governed by the same factor. With these facts in mind, it is then up to those who are actually processing parts to employ the changes that can be made to occur and be beneficial to the part being treated."

DIESEL LOCOMOTIVES

To Be Used in Competitive Experimental Operation

LOOKING forward to post-war improvements in its motive power, the New York Central System has placed in experimental operation two Diesel freight road locomotives of 5400 horsepower each. This is a step in a program of experimentation with various types of motive power on a competitive basis in actual operation on different lines.

Built by the Electro-Motive Division of General Motors Corporation, the two new locomotives are each in four units, every unit having a 2-cycle, 16-cylinder oil engine There are two four-wheel trucks under each unit and each truck has two traction motors The total weight on drivers is 451 5 tons for the entire four-unit locomotive.

The program for post-war improvement in motive power also includes the purchase of four 6000 horsepower Diesel passenger locomotives, and a super-steam locomotive of 6000 horsepower, designed by New York Central's Equipment Engineering Department collaborating with American Locomotive Company.

SHEET THICKNESS

Measured by X-Rays in a Steel Mill

WHITE-HOT sheet steel, at a temperature as high as 2000 degrees, Fahrenheit, and moving at a speed of 20 miles an hour as it emerges from a rolling mill, can have its thickness accurately measured by x-rays. This new development is described as follows by Dr. William D. Coolidge, General Electric Vice-President in charge of research:

"X-rays may be used as a thickness gage without the necessity of making mechanical contact with the work as, for example, in the rolling of sheet steel where, through adjustment of the mill, the thickness of the sheet must be kept within certain narrow limits.

"With an x-ray outfit below and an ionization chamber or other x-ray intensity measuring device above the sheet, it becomes possible through the measurement of x-ray transmission to have a constant indication of thickness and, if desired, to have the x-rays themselves control the mill so as to maintain automatically a constant thickness of the steel sheet."

Metals in Industry

(*Continued from page 105*)

matrix surrounding the steel particles.

The resulting parts can then be heat treated (at temperatures below 1650, Fahrenheit) to improve their properties. Sinter-brazed parts are claimed to be as strong as machined steel and, in the case of precise, complex shapes, can be made many times faster.

The other development is the commercial-scale manufacture, by Chrysler Corporation's Amplex Division, of self-lubricating aluminum bearings from aluminum powder Various technical problems in the working of aluminum powder had to be overcome. Porous, oil-retaining aluminum cylindrical, flange, and thrust bearings are now in regular production and other machine parts can also be made. Aluminum has recently been shown to be a good bearing metal, and its light weight is a real advantage in some types of machinery.

TINNED CAST IRON

Makes Satisfactory Base for Babbit

BABBITTED bearings are those in which a strong-metal shell is coated with a thin layer of soft anti-friction metal, now usually a lead-base alloy. Steel shells are commonly used rather than the cheaper cast iron, because of the difficulty in producing a bond between the cast iron surface and the babbitt layer.

A recently developed process for the preparation of metal surfaces, the Kolene process, has made possible the cheap, quick, and dependable tinning of cast iron, so that the tinned iron may serve as a base for babbitting. So satisfactory has this bonding proved to be in service that Cooper-Bessemer Corporation now uses high strength cast iron (Meehanite) babbitted bearings, without any anchor grooves, for heavy duty use in Diesel engines.

The problem in "tinning" cast iron has been the graphite present in the iron, which prevented metal-to-metal bonding. In the Kolene process the graphitic carbon is oxidized away at the surface of the metal and the iron oxide formed at the same time is later dissolved but without freshly exposing new graphite flakes.

The oxidation is accomplished by immersing the casting in a special molten alkaline salt bath, containing a catalyst, at about 800 degrees, Fahrenheit. Removal of the iron oxides is done in a very hot (about 250 degrees, Fahrenheit) water solution of certain alkaline salts. The work is rinsed in water and in hydrochloric acid and then fluxed prior to tinning.

The process (or an electrolytic modification of it) has other established commercial uses for cleaning metals generally, especially prior to plating, rustproofing, and so on. It is able to remove heavy accumulations of carbon, grease, coked oils, drawing compounds, and so on, but it not applicable to aluminum or magnesium alloys.

Current Bulletin Briefs

Conducted by K. M. CANAVAN

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below)

HOME DEHYDRATORS AND HOME DEHYDRATION, by Donald K. Tressler, is a seven-page reprint from *General Electric Review* giving construction details about different types of devices for this purpose, as well as some information as to their application to various foods. Detailed drawings are presented. *Publicity Department, General Electric Company, Schenectady, New York.—Gratis.*

CALLIFLEX BI-METALS is a four-page bulletin giving technical data on the various types, thicknesses, and sizes of these materials as temperature-responsive elements in automatic control. *Calite Tungsten Corporation, 540 39th Street, Union City, New Jersey.—Gratis.*

EMERSON-ELECTRIC AIRCRAFT MOTORS is a 28-page booklet illustrating and describing these motors which feature high-speed operation and light-metal construction. Illustrations, drawings, and several pages of specifications are given. *The Emerson Electric Manufacturing Company, 1824 Washington Avenue, St. Louis 3, Missouri.—Gratis.*

FUEL CONSERVATION MANUAL has been prepared through the co-operative efforts of manufacturers of automatic heating controls. It indicates the purpose and application of various types of controls from the standpoint of heating and maintenance of buildings other than private homes. *Fuel Conservation Council for War, 500 West Oklahoma Avenue, Milwaukee 7, Wisconsin.—Gratis.*

GREENLEE HANDY CALCULATOR is a heavy cardboard, soil-proof rule designed to solve woodworking problems. By adjusting the dial you can find comparative hardness, weights, and shrinkage as well as converting linear to board feet and determining slope per foot in degrees. *Greenlee Tool Company, Rockford, Illinois.—Gratis.*

BAND FILING TO PRECISION TOLERANCES is a four-page bulletin outlining the advantages of continuous file broaching and information on types and specifications. *Continental Machines, Inc., 1301 Washington Avenue, South, Minneapolis 4, Minnesota.—Gratis.*

ALLOWABLE CONCENTRATIONS OF LEAD AND CERTAIN INORGANIC COMPOUNDS is a booklet setting safe limits for the amount of metallic lead, lead carbonate, lead sulfate, lead oxides, lead nitrate, and lead chloride allowable in the air of workshops to safeguard the health and efficiency of workers. This booklet also covers physical and chemical properties, methods of tests, and a bibliography. *American Standards Association, 29 West 39th Street, New York 18, New York—20 cents.*

MUZAK AT WORK is a booklet based on the opinions of management, labor, science, and government regarding functional music. The data presented are based on research, experience, and actual production. In addition a description of Muzak facilities and service of "planned work music" is given. *Muzak Corporation, 229 Fourth Avenue, New York, New York.—Gratis*

ADHESIVES is an eight-page catalog containing details, requirements, and classifications of several types of adhesives, fabric coatings, binders, and sealers, together with instructions for application and information on standard containers and approximate shipping weights. *The B. F. Goodrich Company, Public Relations Department, Akron, Ohio.—Gratis.*

WELTRONIC VARIABLE SPEED CONTROL FOR D.C. MOTORS FROM A.C. POWER is a four-page bulletin on this electronic control—a self-contained unit—which eliminates the need for separate transformers for driving lathes, drill presses, conveyors, printing presses, and other types of machines. *Weltronic Company, Detroit 19, Michigan.—Gratis.*

ARO PNEUMATIC TOOLS FOR INDUSTRY is a 32-page catalog containing illustrations and specifications of these rotary pneumatic tools for small tool jobs such as drilling, grinding, burring, and metal sanding. *Aro Equipment Corporation, Bryan, Ohio.—Gratis.*

THE MIDDLE OF THE SHOP, by Tom Saffady, is a 16-page booklet outlining the importance of better human relations as a source of information for the promotion of production efficiency. *Sav-Way Industries, 4875 East Eight Mile Road, Detroit, Michigan.—Gratis.*

VICTAULIC PIPE COUPLINGS AND FITTINGS is a 34-page combination catalog and engineering manual listing flexible couplings and fittings and their use in industrial, mining, petroleum, shipbuilding, and water works. *Victaulic Company of America, 30 Rockefeller Plaza, New York 20, New York.—Gratis.*

AR-MOORED TIES FOR HIGH TRACK CAPACITY is an eight-page booklet outlining and illustrating the advantages of these ties, with a list of the information needed for quotations. *Koppers Company, Wood Preserving Division, Pittsburgh, Pennsylvania.—Gratis. Request this on your business letterhead.*

HOLD EVERYTHING is a bulletin presenting a new and improved application of microfilm to pencil engineering drawings made on transparent paper, as well as other valuable papers and documents, and pointing out savings in time, money, and space. *Microcopy Corporation, 2800 West Olive Avenue, Burbank, California.—Gratis.*

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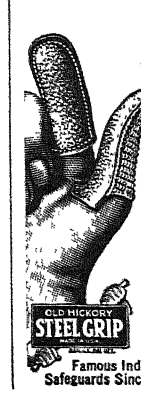

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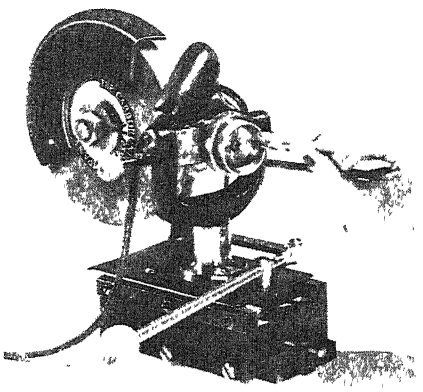
There are just four simple steps in operating the drill sharpener. First, insert drill, tighten chuck. Second, look through the magnifying glass and line up lip of drill on the alinement bar. Third, depress grinding bar slowly and release. Last, revolve the chuck and repeat the third operation. An inexperienced operator can do a perfect job after a few minutes' instruction.



Fast, accurate drill sharpener

Every size of drill requires a separate bushing, ten of which are supplied with each drill sharpener. Extra ones are available.

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REPORTED to be the first commercially successful one coat direct-to-steel white porcelain enamel, Mirac requires no special bond or pickling equipment. Nor does it need special handling. It is reported to have adherence and can be fired at 1500 degrees, Fahrenheit with a brilliant highly opaque finish as the result.

METALLIZING GUN

ESPECIALLY engineered for high-speed production spraying of low melting point metals, a new metallizing gun which uses ⅛-inch zinc, tin, lead, solder, babbitt, cadmium, or fine gage copper and copper alloys, exhibits spraying speeds which exceed by far any yet attained with these metals. Rates of deposition, in pounds per hour, include: zinc, 40; tin, 70; lead, 110; solder, 90; babbitt, 75.

Regardless of the type of wire employed, no gear changes are necessary to achieve these high speeds. Any spraying speed within the prescribed ranges is automatically obtained, and maintained hour after hour. Air pressure fluctuations, it is reported, do not affect operating efficiency.

In common with all Metco metallizing guns, this Type 3E is equipped with a Universal Gas Head, which allows the tool to be operated on any commercial gas—in conjunction with oxygen and compressed air

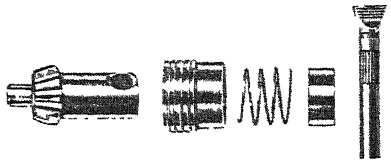
Typical applications where this gun will cut manufacturing costs and broaden the opportunities for spraying low-melting-point metals on a production basis include: corrosion-resistant coatings on iron and steel structures and equipment; water- and chemical-resistant linings for storage tanks and degreasers; conductive and soldering surfaces on glass, plastics, and carbon products.

APPLIANCE TESTER

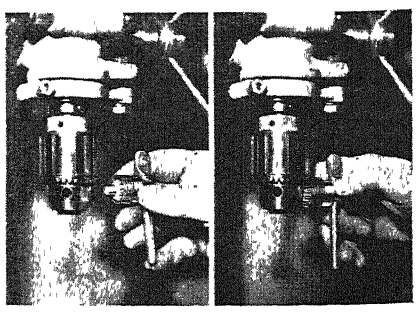
BUILT to operate at the extremely low range of 0—20 watts as well as a high range to 2000 watts, a new device tests all electrical appliances from bell transformers and clocks to electric ironers and ranges operating on the 220-volt three-wire Edison system. This tester measures actual load values of volts, amperes, and watts and quickly locates trouble in A.C. appliances while in actual operation.

CHUCK-KEY SAFETY

A NEW safety device called the "Kee-Jector," which is applied to the standard lathe or drill-press chuck key, has been developed by Lee H. Jernigan, of Safety-Specialties. Designed to prevent accidents which occur when machine-tool operators neglect to remove the chuck key from the chuck before the power is



Above: Standard chuck key and parts of the ejector. Below: When key is inserted, spring is retracted

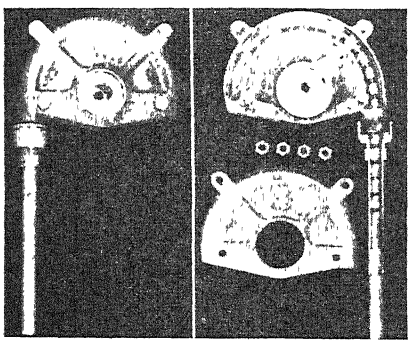


turned on, the Kee-Jector, made in a complete range of sizes, fits as a guard on the chuck key of any sized drill press or lathe and "ejects" the chuck key the moment its job is done It is impossible to leave a chuck key engaged in the chuck when this device is used. The device is simple and foolproof and in no way handicaps the worker in the proper use of the key

PUSH-PULL CONTROL

PROVIDING positive rotary-motion action from push-pull operation, a new Radian unit was specifically designed for use in connection with propeller governors carburetor air controls, supercharger controls, and similar aircraft installations Made by Simmonds Aerocessories, Inc , as an adjunct to the Simonds push-pull controls the versatility of the device points to many post-war marine, automotive, and industrial uses

Compact, strong, and weighing approximately 12 ounces, the Radian unit, which replaces the more cumbersome pulley-and-cable and rod-and-bell-crank assemblies, has but three basic parts a housing, a lever-arm, and a bushing The housing contains the



Left: Assembled push-pull control. Right: Interior of the control, showing how rotary motion is produced

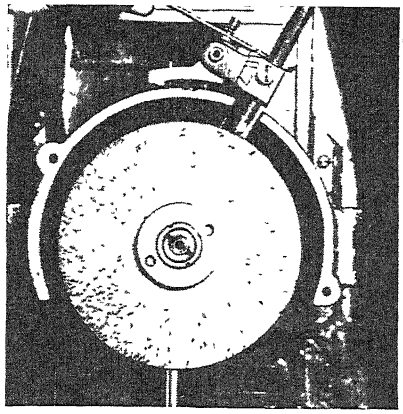
track of the linkage path, the lever-arm carries out the angular travel, and the bushing transfers the angular travel to the shaft to be actuated. Serrated teeth provide for fine adjustment between the lever-arm and the shaft it actuates.

WINDER ROLLS

ONE COMMON application of industrial wood rolls is for winding goods of one kind or another as they involve a manufacturing cycle Recently the Rodney Hunt Machine Company has standardized on two types of constructions for such rolls. One type embodies "shaftite" anchorage of shafts to the wood The other type (for especially low cost) employs a simple countersunk ring in the end of the wood that helps to reinforce the shaft. The wood used is especially selected for its light-weight and well seasoned qualities.

WHEEL DRESSER

THE "Jiffy" grinding wheel dresser, designed for mounting on any standard toolroom surface grinder, becomes an integral part of the grinder on which it is mounted and is always ready for



"Built-in" grinding wheel dresser

wheel dressing, regardless of the position of the wheel relative to the table

When using this attachable dresser, made by the Florian Manufacturing Company, it is not necessary to disturb the work set-up. As occasion demands, the wheel can be dressed in five seconds Adjustable to dress absolutely true, it is simple to mount and fits all standard surface grinders

PIN SETS

STRONG, compact cabinets completely furnished with precision pin sets in number drill, letter drill, and fractional sizes are announced by United Precision Products Company. The pins are of the finest quality gage steel, hardened to 60-63 Rockwell C scale. Brass strips with letter, number, or fractional size permanently fixed in clear easily-read white, identify each gage at its position Gages are progressively stored for instant pickup Complete protection is afforded the gages from moisture, corrosion, and dirt, and the complete sets are at hand for immediate selection and use, without loss of time

SAFETY MATS

IMPROVED steel safety mats, manufactured by William F Klemp Company, include a design feature which has proved a decided addition to non-skid protection. This is a slight crimp or center bend in one side of the strong steel mesh. These steel mats, which

Steel mat (inset) promotes safety

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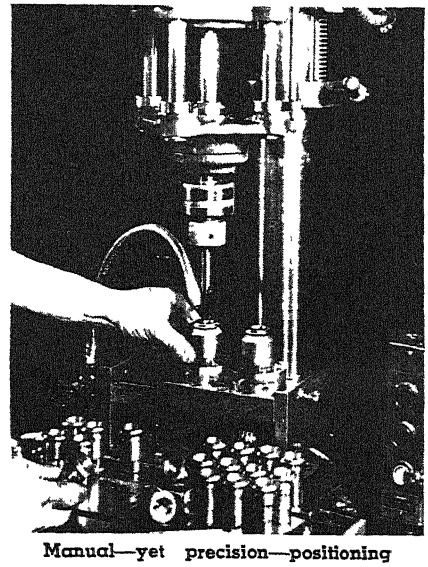
PRECISION TAPPING SPEEDED

USE OF manual positioning and elimination of chucks or clamps on a simple, new non-locking slide type fixture has speeded up precision tapping of ordnance parts at Manufacturers' Machine Service Company This fixture, incorporated on a "Detroit" light duty lead screw type tapping machine, permits tapping on a continuous basis The simple slide fixture, built in the company's tool room for holding and positioning the work, was arranged to operate on an automatic tap and return stroke cycle stopping at the top. The fixture incorporated two non-locking work holders mounted on a slide that can be moved "right" or "left" on ground ways below the tap. The work in either work holder will be accurately located below the tap when the slide is moved from one side to the other against the stops.

All the operator has to do is to remove a finished piece and place a new



Manual—yet precision—positioning

piece in the same work holder while the other piece is being tapped He then moves the slide over as soon as the tap clears the finished piece in the other work holder. With this arrangement it is possible to operate the machine on a "continuous repeat" cycle, reducing floor to floor time to less than 10 seconds per piece. It thus speeds up production by actually making the operation *less* automatic.

SHROUDED COUPLING

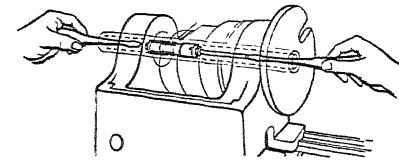
PROTECTION of operators against catching of clothing or incautious handling is embodied in a new shrouded flexible coupling announced by Lovejoy Flexible Coupling Company.

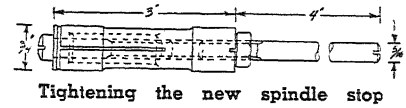
The essential feature of this new protection is an outside steel collar which holds the load cushions of the coupling in place. An extension of this collar, which encircles the coupling, safeguards material and fingers from the heads of the bolts that secure the load-cushion retainer The bolt heads are concealed, yet easily and conveniently reached when necessity arises.

This improvement effects more compact design with over-all smoothness of external surface.

SPINDLE STOP

PRINCIPLE feature of the new Rieger spindle top is its expanding collet action. While the front end of the device is held in place with one screwdriver, a turn on another at the rear end makes the stop expand to tighten itself in the hole of the headstock spindle This is said to avoid the scarring or burring of the walls.





Tightening the new spindle stop

The spindle stop is equipped with a 5/16 by 4 inch extension for limiting hollow work and for protrusion into the chuck for stopping short pieces The extension is soft so that it can be turned down to a smaller diameter if desired. It can be removed for positioning solid pieces. The body of the device is 3 inches long and slightly under ¾ inch in diameter when contracted.

Used for repeat operations on the lathe, the spindle stop limits the entrance of work into the spindle hole. It can be utilized with or without a chuck.

AIR SEPARATOR

A SELF-DRAINING compressed-air separator, which eliminates the need for external traps or the uncertainties of manual draining, has been developed by the Johnson Corporation. It has a complete trap mechanism built in, which releases from the separator, automatically, all the water, oil, and other moisture that has been removed from the compressed air. The entering air is first allowed to expand slightly, thereby precipitating most of the entrained moisture. Then it passes through a labyrinth of coarse wire mesh, changing direction of flow abruptly many times, and surrendering the remaining particles of foreign matter.

The trap mechanism is simple and compact, with spherical float and chrome steel valve and valve seat. It

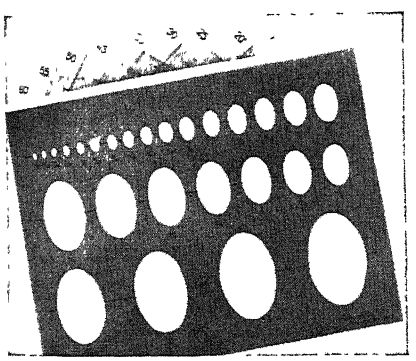
is mounted on the bottom plate of the separator body, and can be quickly and easily removed for inspection or cleaning All the moisture that has been removed from the compressed air drops to the bottom of the separator, and when the level of the accumulated liquid is sufficient to raise the float, the valve opens and the liquid flows out the drain.

SUPER TEMPERING

A FURTHER development of the quench tempering solution, reported in these columns in our February issue, makes it possible to impart instant maximum hardnesses to friction wearing parts and high speed steel tools that operate with a uniform or rotary motion This hardening solution, known as Super Temp, by which both hardening and drawing are accomplished simultaneously, will produce "glass hardness," but at a sacrifice of toughness Therefore, the use of Super Temp is not recommended for impact tools but has proved particularly valuable for handling steel gears, pinions, axles, and high speed cutting tools. The resulting wearing surfaces are claimed to be friction and abrasion resistant.

ELLIPSE GUIDES

SAVINGS up to 50 percent in time on production illustration jobs ("visuals") are being effected through use of a new series of precision-cut ellipse templates. Meeting professional accuracy require-



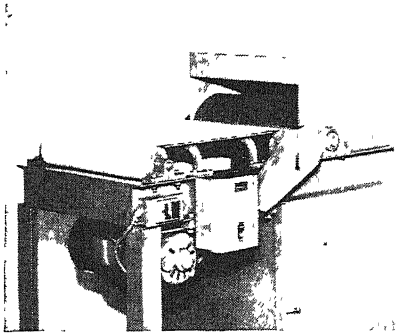
Available in sets or separately

ments, these guides are .020-inch-thick celluloid templates and are made in a set of 10, with angles from 15 to 60 degree by 5 degree increments.

Equally efficient for either pencil or ink, they eliminate the time-consuming geometrical development of ellipses by the plot method. They enable the untrained as well as the professional to draw ellipses with equal accuracy and speed in a small fraction of the time ordinarily required. Vertical and horizontal axes are clearly indicated for ready location and adjustment to position.

DISINTEGRATOR

A NEW development in disintegration of materials and food stuffs is a machine, manufactured by the Franklin McAllister Corporation, which includes a steel drum containing thousands of teeth on its outside diameter. These will disintegrate almost anything that a steel saw will cut, from hard metals to soft



One type of disintegrating unit. The head can be designed for any job

food stuffs. The list of materials which it has disintegrated successfully ranges from nickel and stainless steel to wood, rock wool, and chewing-gum base.

The picture shows a small, automatic feed unit with a 20-inch drum designed for a food product The disintegrator head can be made in practically any size and assembled into almost any machine that best suits the particular product requirements.

RUST PREVENTIVES

TWO types of rust preventives, released by the Technical Processes Division of the Colonial Alloys Company, actually are metal cleaning solvents which leave protective films that prevent rust and tarnish. They are identified by the names Cyclodiene and Percyclodiene.

Both are used as short-time simple immersions at room temperature and are used in an open tank made of metal, glazed ceramic, or other material. Neither will attack metals, as they are neutral and contain no acids or alkalies. Cyclodiene films dry in about 20 minutes, leaving rust-inhibited clean surfaces for a short time thereafter. Percyclodiene films will remain for about 30 days, leaving rust-inhibited clean surfaces for quite some time thereafter

A quick dip into either one of these rust-inhibitive solvents prior to or between inspection and final finishing operations, will protect the work from rust and corrosion Penetration is excellent, and protection is afforded to threaded parts, joints, interstices, and crevices.

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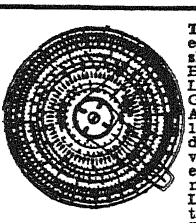

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Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G INGALLS

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YEARS AGO John C Lee devised and made a grinding and polishing machine (see "A T M," page 160) in which the telescope mirror moved in a bath of liquid abrasive He could start it running, go to bed, and get up to find the main part of the roughing-out job finished Now comes O Magnussen, 514 Ricketts St, Danville, Va, with the semi-automatic machine shown in Porter's sketch (Figure 1) drawn from the original.

Magnussen writes: "I made this machine from worm gears and shafting, and a novel feature of it is the automatic abrasive feeding device. The grease cup fastened to the cast iron lap makes 1/6 turn during each revolution of the lap The abrasive is mixed with soap, which acts as a vehicle. The parts are easily removed and cleaned between grinds I use a similar cup for polishing, except that its threads are finer (40 per inch). This method doesn't seem to leave zones, since the rouge mixture is spread through channels in the lap"

Figure 2 shows a neat 6" reflector

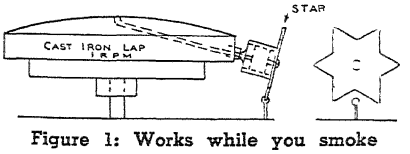

Figure 1: Works while you smoke

with drive made from a hand-wound phonograph motor, built by Magnussen, who teaches machine shop work.

H. H. SELBY contributes the following note:

"In using a slit or a pinhole for testing precisely on the axis, the usual method, which I have used for ten years and which Gaviola published a few years ago, is as sketched (Figure 3): A is a fairly plane-parallel, unsilvered diagonal, such as a 20 x 26 x 0.5mm hemocytometer cover glass. B is a plate containing the slit or hole. C is ground or opal glass. D is the illumination system. E is the eye.

"When A is unsilvered, a reflection occurs at each surface, giving an overlapping of shadows which can be confusing. Also, only 0.5 to 1.0 percent of the light at the pinhole reaches the eye when testing uncoated mirrors and, if the diagonal is thick, aberrations are introduced. This doubling of the beam, also spherical aberration and astigmatism, can be minimized by making the diagonal thin, but 0.5mm is nearly the limit for glass, considering that the surface should be plane within, say, 2 to 4 fringes Pellicles are admirably thin, but are fragile. and interference phenomena within the membrane are troublesome.

"The second surface can be coated with a non-reflecting film of fatty acids or fluorides The fluoride films are particularly satisfactory and commercially available If a 0 5mm diagonal, flat to ± 3 fringes on one side and fluoride coated on the other, is employed, no troublesome doubling will occur and illumination will be uniform, but relatively weak. By applying a 50 percent reflecting coating of aluminum or silver to the flatter surface, the light reaching the eye will be the maximum possible—3 5 times that from an untreated surface The remaining imperceptible residual doubling is also reduced in like ratio.

"From the above, it is seen that the ideal arrangement is a thin, flat-surfaced diagonal, having the flat side 50 percent reflective, the reverse side nonreflective. With such an arrangement, the lowest focal ratios found in objectives can be examined with complete freedom from artifacts."

IN THIS department, September 1943, appeared a note by Haviland, on the Barlow lens, and in the May number succeeding there was one by Wates. It turns out that these were partly erroneous Since an editor is supposed to edit, these errors become automatically your scribe's—which makes three of us for you to boil in oil, so light up the fires and pile on the faggots. Note however how frankly—almost gleefully—we three villians admit our errors and please be good to our families after we have expired.

The detective who spotted the errors

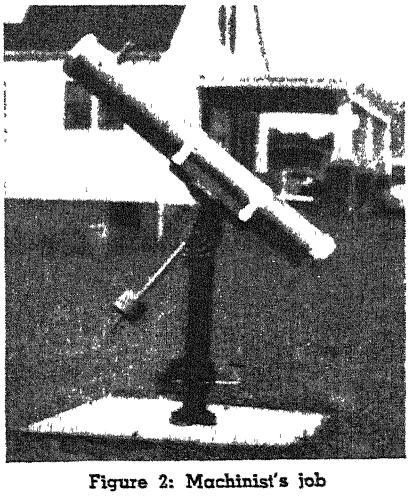

Figure 2: Machinist's job

is C. R Hartshorn, 1244 W. 109th Place, Los Angeles, California, and he didn't want his name mentioned He said he didn't want readers to think him one of those disputatious, contentious persons who miss no chance to jump on others However, your scribe, who dealt with Hartshorn for a long time when he was in the famous Amateur Roof Prism Gang (where he wanted to make roof prisms gratis for Uncle Sam, just to take a punch at the Krauts and Japs), can testify to the contrary, and gives his name for another reason—because he appears to have had experience with Barlows and should in future be made to work for other amateurs who may need help on them. It is the custom of this department, when questions arrive on some special phase of the

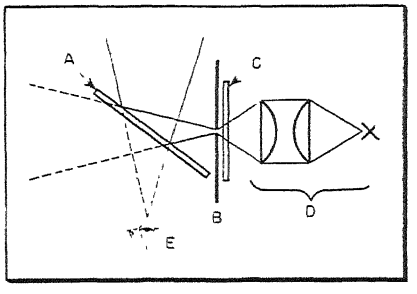

Figure 3: Testing on the axis

hobby, to pass them to other amateurs who are known to have gained experience in those phases

Hartshorn writes: "I thought some of your regulars would rise to the occasion and point out the errors but, as they haven't, I am sticking my own neck out. Haviland proposes a Barlow of —18" f.l., to be placed 2" inside the focus of a telescope of 48" f l. He figures correctly that the e f.l of the combination will be 54", but then goes on to assume that the eyepiece will move out 6", and that the magnifying power will be quadrupled. Actually, the eyepiece will move out only $^1/_4$" and the amplification will be only 12$^1/_2$ percent. He is just dealing with the tip of a theoretical cone of light 54" long The ratio is $2^1/_4 \cdot 2 : \cdot 54 \cdot 48$

"As a check, although the formula Haviland used is entirely adequate, I have just traced the paths of the rays trigonometrically through a hypothetical —18" Barlow and it came out 2.249". I have used a Barlow for years, designed and made my own—flint and crown—and observed with it and others with sundry eyepieces.

"Perhaps Wates also is a little off the beam. If you had a Barlow that would amplify X4 at 2" inside focus, the f.l. of the Barlow would be —2 2/3". If you then moved it to 1" inside focus, the amplification would be X1.6. If you moved it 6" inside focus you would see nothing at all through it, because the rays would then be divergent. At 2 2/3" inside focus they would be parallel, the secondary focus at infinity.

"Any particular Barlow has the same amplifying power when placed at the same distance inside focus, no matter what the telescope."

Hartshorn gives some specific figures. For a primary focus at 48", Barlow of —2 2/3" f.l., 1" inside focus, amplifica-

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tion is, as already stated, X16 and power of telescope with 1" eyepiece is 76.8. Corresponding figures for 2" inside focus are X4 and 192, for 2½" inside focus X16 and 768, for 2⅝" inside focus X64 and 3072

Haviland's response to Hartshorn's letter is candid. "Hartshorn is right I have a string of alibis as long as your arm, but Hartshorn is right Here is the correct solution

"Suppose that a Barlow lens (Figure 4) of focus $-F$ is placed p inches inside the focus, A, of a telescope. The new focus, B, will be at a distance q from the Barlow The relation between these distances is $1/q - 1/p = 1/f$.

"The ratio q/p = magnifying power

"If we have a Barlow of -2 2/3" focus, placed 2" inside the focus of the telescope objective, we get $1/q - 1/2 = -1/2\frac{2}{3}$ and q therefore = 8.

"In the above, $\frac{1}{2}$ takes the minus sign, in accordance with the direction of light

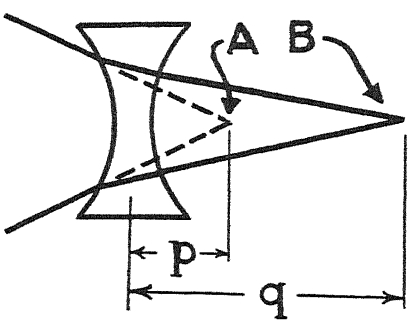

Figure 4: Haviland's drawing

from A toward the left (both images on same side of lens).

"The magnifying ratio then is $q/p = 8/2 = 4$

"Caution In using a Barlow with reflecting telescopes, avoid high amplifications, else the color correction will be poor. A -3" focus Barlow to give an amplification of not more than 1.5 or 2 will be the top useful limit. This works out to $p = 1\frac{1}{2}$" (inside focus), $q = 3$" (new back focus) and $q/p = 3/1\frac{1}{2} = 2$ (amplification)."

Wates, to whom Hartshorn's letter was next passed, writes: "Hartshorn is right, I was off the beam—I took Haviland's formula as my premise. I must admit I was surprised that the result of moving the lens within reasonable limits is very small, as I had understood that one could produce any amplification by moving the Barlow back and forth."

And thus the sins of Wates pass into the body of Haviland, and then the combined sins pass on into the frail body of your scribe, for letting the errors get by, just as in the 21st verse of the 16th chapter of the biblical Book of Leviticus ("The Devil can quote scripture."—old proverb): "And Aaron shall lay both his hands upon the head of the live goat, and confess over him all the iniquities of the children of Israel, and all their transgressions in all their sins, putting them upon the head of the goat, and shall send him away . . . into the wilderness."

Your goat, only too glad of a pretext to hunt up a good wilderness, goes willingly—tail up in the air.

RIGHT in the middle of a war there has been a rush among Englishmen to join the British Astronomical Association, mainly by persons who, because of the blackout, have discovered that above modern city streets there are stars The new List of Members recently received in this country contains about 1200 names, mainly British but also scattered all over the planet Of these, only 30 are Americans but there no doubt would be more if more of us were familiar with the Association's good publication, *The Journal* To obtain it, the easiest way is to seek to join Nominations must be signed by one member from personal knowledge and your scribe would try to contribute that help for any except convicts or those who should be The costs are about $6 for the first year and about $4.25 a year thereafter. Over there they really go in for astronomy, and a few of them for telescope making about which there are occasional articles The monthly meetings of the Association are reported verbatim—oral discussion by this member and that—in each number

COARSE diffraction gratings may be made at 10 or 20 cents apiece if made in quantities, by a method described in a short article in *American Journal of Physics* (57 East 55th St, New York, N. Y.), April 1944 by Warner W Schultz, Reed College, Portland, Oregon.

He knew that gratings had been made by photographing a series of parallel lines but getting such lines is not easy. Easier, it occurred to him, would it be to stack up alternate layers of black and white sheets of paper and photograph these.

A simple rack was built, one face of it being of glass, tilted at 45 degrees, and the papers were stacked 6" deep against this It then was placed vertical, clamped, and the glass removed

Focussing the camera was critical, so a finer screen was made by grinding the glass with No 600 Carbo or finer, and focussing was done with an eyepiece (details of an even better method of focussing are described in the original article) Special film of high resolving power, lantern slide plates, or microfilm, may be used It is also hoped that gratings of 10,000 lines an inch may be produced using a new Eastman film of high resolving power

Such gratings may be used for direct observation of spectra

AUTHOR of the well-known book "Applied Optics and Optical Design," Professor Alexander E Conrady, died June 16 at his home in London, aged 78 years. He was formerly Professor of Optical Design at the Imperial College of Science and Technology, London, and previously lens designer at W. Watson and Son, Ltd., of London, manufacturers of microscopes. He is survived by three daughters, one of whom, Hilda G. Kingslake of Rochester, N. Y., the wife of Professor R. Kingslake, is herself the author of several optical papers. She is also the mother of Professor Conrady's only two grandchildren, both of whom were born in the United States

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COVER: As he solders armature connections on the collector of a synchronous converter, this workman adds one more link in an electrical chain that eventually will play an important part in aluminum production. These converters change alternating to direct current. In the finished machine the "spiderweb threads" will be bent around the central unit. Photograph courtesy Westinghouse Electric and Manufacturing Company.

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By A. P. Peck

DON'T WAIT FOR GEORGE

THE hectic days of preparing for "national defense," prior to Pearl Harbor, and for all-out war immediately thereafter are not far enough in the past to be completely forgotten Everyone blamed everyone else for slow conversion to war production, and industry in general had its pants soundly kicked from all directions. Yet, despite handicaps. industry muddled through. The tools of war were fabricated and delivered in record time and in record quantities.

Now, whether you like to believe it or not, industry is terribly close to a similar situation, one in which the beat of drums and the waving flags will be lacking. As the end of the war with Germany draws near (and this is written with full cognizance of the dangers of "complacency"), industry approaches another conversion job. This one is to peacetime production and here the stimuli of war will not be present. It will be a heart-breaking job, filled with grief and hard work. So far as is known, real honest-to-goodness governmental plans for this important work are as yet lacking.

Thus industry is faced with the problem of making its own plans for the day after V-day. These plans must be aimed from a platform of knowledge of what has gone before in the way of controls, labor problems, and the like. Industry itself must work out these plans in minute detail and be ready to apply them quickly and with a minimum of lost motion. If industry fails in this respect, its pants will be even more soundly kicked than they were a few years ago

Never before has industry had a brighter horizon in prospect. How bright will be the fulfilment of the promise depends on industry taking the initiative and planning now for production for peace. It will be a tougher job than war-production planning. But, once the hump is passed, industry will have shown again that it is no mewling baby, dependent entirely upon its nurse. It will have shown once more that it cannot only deliver the goods but that it can plan the delivery as well

UBIQUITOUS PAPER

TODAY everyone is being asked to save paper Magazines and newspapers are on short rations. People in every walk of life are becoming paper conscious. Although civilians are suffering to a minor degree as a result of paper shortages, a bright gleam is visible for the future.

Waterproof papers of many types have been developed to fill military needs ranging from cargo parachutes to wraps for a number of things from airplane engines to blood plasma. Paints and other liquids are being packed in paper "cans." In more ways than can be told now because of Ol' Man Military Secrecy, paper is serving to do jobs that it could never do before.

A brief survey of patents issued recently shows a large number of developments in the paper field whereby the lowly pulp can be processed into forms that will be waterproof, flexible, fusible, and resistant to oils and greases

It is apparent that here is no *ersatz* flash-in-the-pan that will disappear from the industrial field once the emergency is over. The improvements in paper are such that they should, with the necessary amount of diligent application, make permanent places for themselves in many lines.

WHAT ABOUT LIQUID FUELS?

ALTHOUGH the extent of the petroleum resources in the earth is a controversial subject—and has been so for many years—it is unanimously agreed by technologists that processes for the production of alternate liquid fuels should be investigated and developed now Thus, in a plea for a long-range research program based on sound scientific and industrial principles, Dr. Robert E Wilson, president of Pan American Petroleum and Transport Company, makes the following statement in a report to the American Chemical Society·

"Regardless of the possibility of adequate petroleum supplies for several decades to come, the probable ultimate source of raw materials for liquid fuel manufacture lies in those solid substances which will have to be mined, such as oil shales, tar sands, and coal The sum total reserves of bituminous matter contained in these substances is tremendous, and they could supply our probable needs of liquid fuels for more than a thousand years"

Disclaiming any intention of creating the impression that he considers the large-scale use of alternative sources of liquid fuel imminent or definitely necessary to "oiling the next war," Dr. Wilson asserts that there will be increasing use of various intermediate processes to help stretch available petroleum supplies. This will be done in an endeavor to maintain production costs similar to those now prevailing. These intermediate processes will have the added advantage of making available a vast accumulation of technical knowledge that could be obtained in no other way

To end on a Pollyanna note: There is less need for concern today about the future of our liquid fuel supplies than there was immediately after World War I, when pessimistic estimates of crude reserves caused widespread concern and when there was no thought of making gasoline from coal

GLASS IN FABRICS

FABRICS woven from flexible fibers of glass are not by any means a new product, but they are materials that you are going to hear a lot about in the future. Present and continuing experimental work has brought forth a number of coated and uncoated fabrics that have remarkable properties Various synthetic resins have been applied to fiberglas cloths, making them far more resistant to the effects of flexing than are uncoated fabrics Then, too, glass fibers have been combined with cotton and asbestos to produce fabrics that are strong in one direction and that lend themselves very well to lamination where strength in both directions can be had by correctly placing the succeeding layers

Much of this work with glass fabrics is still so new that details are not yet available But these materials are going to pop up in unexpected places where their resistance to heat, acids, and oil give them advantages over other materials now in general use

FOR FUTURE REFERENCE

ONE guess about the future of synthetic rubber, based on a thorough knowledge of the rubber business, is that the existence of America's synthetic rubber production facilities will so influence cost that these facilities will pay for themselves within four years after Far Eastern plantations resume normal production. The influence of synthetic, thinks James J. Newman, vice president of Goodrich, will force raw material costs to a price ten cents a pound lower than it would be if the facilities were not available. . . A power trend is seen in the fact that more Diesels have been installed for marine service alone during the past six years than were in existence in this country prior to 1938. . . Phosphor crystals, light source in fluorescent lamps, have possibilities in production of luminescent plastics and for indirect interior illumination where they will be part of walls and ceilings.

Why CORRONIZING makes one scrub pail last as long as four!

This amazing new armor for metal products keeps them safe against rust up to 4 times as long.

LOOK FOR THIS LABEL
•
CORRONIZING
MAKES METALS LAST
UP TO 4 TIMES AS LONG

SOME of the "wonders" soon to come will be familiar things, which the new "Corronized" label will tell you are 4 times as good a buy as before!

Think of the bonus in your budget when this metal magic makes one scrub pail last as long as four! It will keep refrigerator shelves and hot water heaters rust-free years longer . . . stretch the life of heating and air-conditioning equipment, ash cans and automobile mufflers, kitchen ranges and farm equipment.

Corronizing has been developed thru years of research in the laboratories of Standard Steel Spring Company.

The Corronizing process is available to all makers of metal products. When peace returns, the "Corronized" label will be your guide to greater value in scores of everyday products . . your guarantee of extra years of service without extra cost.

CORRONIZING

Division of

Standard Steel Spring Company

Dept B-4

CORAOPOLIS, PENNSYLVANIA

Other peacetime products of Standard Steel Spring Company are automobile bumpers and springs, precision mechanical coil springs, universal joints, floor gratings and stair treads.

Victory Is Still Many Dollars Away. Buy War Bonds.

Q. What Is Corronizing . . .

A. Corronizing is an inexpensive, tissue-thin armor against rust, made an integral part of the metal by a patented treatment. Corronized metal can be formed, drawn, welded, soldered, sheared, blanked, pierced or embossed with minimum loss of rust-resistance, and offers an ideal bonding surface for paint or other finishes. **Sales and production executives are invited to write for complete information.**

50 Years Ago . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of September, 1894)

MOTOR CARRIAGES — "In the United States, with cobblestone pavements, and with sandy and muddy roads disgracing city and country alike, much has to be done before the work of producing a successful traction engine or motor carriage can be accomplished. But the production of the bicycle has done so much to facilitate progress, and has solved so many of the mechanical problems of the perfect road vehicle, that it seems a pity that the power problem cannot also be solved. The motor is now what is wanted."

CAR DOORS — "Let any practical mechanic, or any practical railroad superintendent, go through any large yard where cars of all railroads are stored, and examine the doors on freight cars, and he will find that with a monkey wrench in his hand he can enter nine-tenths of the cars inside of five minutes, without breaking a seal. This because the fastenings are put on with lag screws, or ordinary bolts with the nuts on the outside of the car. There is no one road that is more subject to criticism in this respect than another, except that a few have apparently realized that this is all wrong, and made a few feeble and unmechanical attempts to better it, with very little real success"

WOOD — "Many of the finest woods in existence are yet unknown, or only slightly known, to the manufacturers of wood in the civilized world. The woods of Central and South America are, perhaps, the most remarkable as well as the least known. In the yet untouched forests of this continent are many woods far finer than any of those now in use These woods range from pure white to jet black in color, and many of them are most beautifully marked and veined"

ALUMINUM BOAT — "The aluminum torpedo boat which Messrs. Yarrow & Co. have constructed for the French government was recently subjected to trial. . . The material of which the hull is constructed is, of course, not pure aluminum, but an alloy consisting of 94 percent of aluminum and 6 percent of copper. . . The chief result of using the lighter metal has been that a speed of over 20½ knots was obtained on the official trial. . . The maximum speed of torpedo boats of this class in the British navy is about 17 knots"

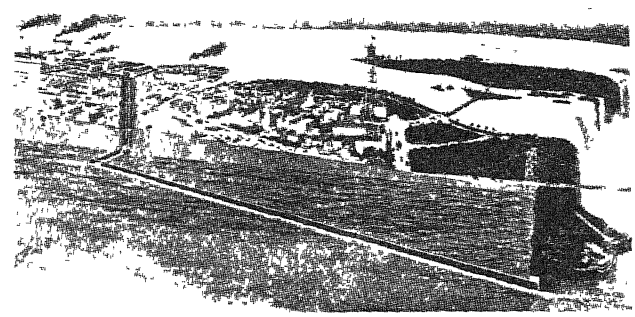
PEANUT OIL — "The report of the American consul at Marseilles contains some facts concerning the manufacture of peanut oil, which is coming into use for various economic purposes. Extraction of oil from peanuts is rapidly increasing, no fewer than seventeen factories being at present engaged in the industry. . The oil is largely devoted to the manufacture of white soap, for which it is highly prized It is also used as salad oil and in the composition of margarin. Large quantities are also sold as olive oil, principally in the United States. A smaller amount is used for illuminating purposes"

FLIGHT — "Mr. Maxim has demonstrated his ability to soar by mechanical means on a scale which will permit a greater lifting power than that necessary to carry the men and machinery, and there can be very little doubt that he will ultimately succeed in soaring through the air, and thus add, as he designs to, one of the most unique and most formidable engines of destruction in modern warfare."

GLASS — "The manufacture of glass has progressed so rapidly in the last twelve years that it may now pertinently be asked what cannot be done with glass. M. J. Henrivaux, a prominent French manufacturer of this article, an original and enthusiastic inventor, has recently proved to us, by means of a veritable museum of curious samples, that everything is becoming possible to the modern glassmaker Even conducting pipes of large diameter have been made of it, tiles, drains, tubs, curtains, furniture, chimneys and even houses"

LOCOMOTIVE HEADLIGHTS — "It is the opinion of a number of locomotive engineers and other practical railroad men witnessing tests of a new improved Pintsch gas headlight recently made in the Delaware, Lackawanna & Western yards at Hoboken, N. J, that the light furnished is at least three times as powerful as that of oil headlights, while at the same time it meets the very important requirement of not in any way obscuring the signal and other lights around the yard."

NIAGARA POWER — "The first mill to make use of the power rendered available by the 7,250-foot water power tunnel at Niagara Falls is that of the Niagara Falls Paper Company, for some months past using 3,000 horse power, to be increased to 6,000 horse power. A concrete subway is also ready for the wires of the Pittsburgh Reduction Company, whose plant is about 2,500 feet from the power house, from which the company will be supplied with about 3,000 horse power for use in the reduction of aluminum The arrangements for the electrical transmission of power to the city of Buffalo are also nearly completed. This power is to be transmitted by means of wires carried upon poles from a 50,000 horse power electric station which the Niagara Falls Power Company have near completion on the main canal. The right of way has been acquired, and all the contracts made for two lines, one of which crosses Grand Island while the other follows down the shore."



OIL FRICTION — "Petroff, who has occupied himself very extensively with the examination of lubricants, has investigated the interior friction of oils by means of an apparatus invented by himself, and has given his results in tabular form and graphically by a series of curves. . It was also frequently observed that samples of the same oil that were received in the factory at different times did not yield the same characteristic curve, though filling all requirements This fact is naturally important to consumers on economic grounds."

BEARINGS — "Ball bearings are successful only when the balls themselves are of the highest quality, and the shells and axles are of the best steel, hardened and ground to the highest perfection. . . The limit of error in the best does not vary more than one-quarter of one-thousandth of an inch, or one-fourth the thickness of tissue paper Such perfection is very costly, and the least dirt destroys the whole gain, for if the balls be stopped by any impediment, they are very soon ruined."

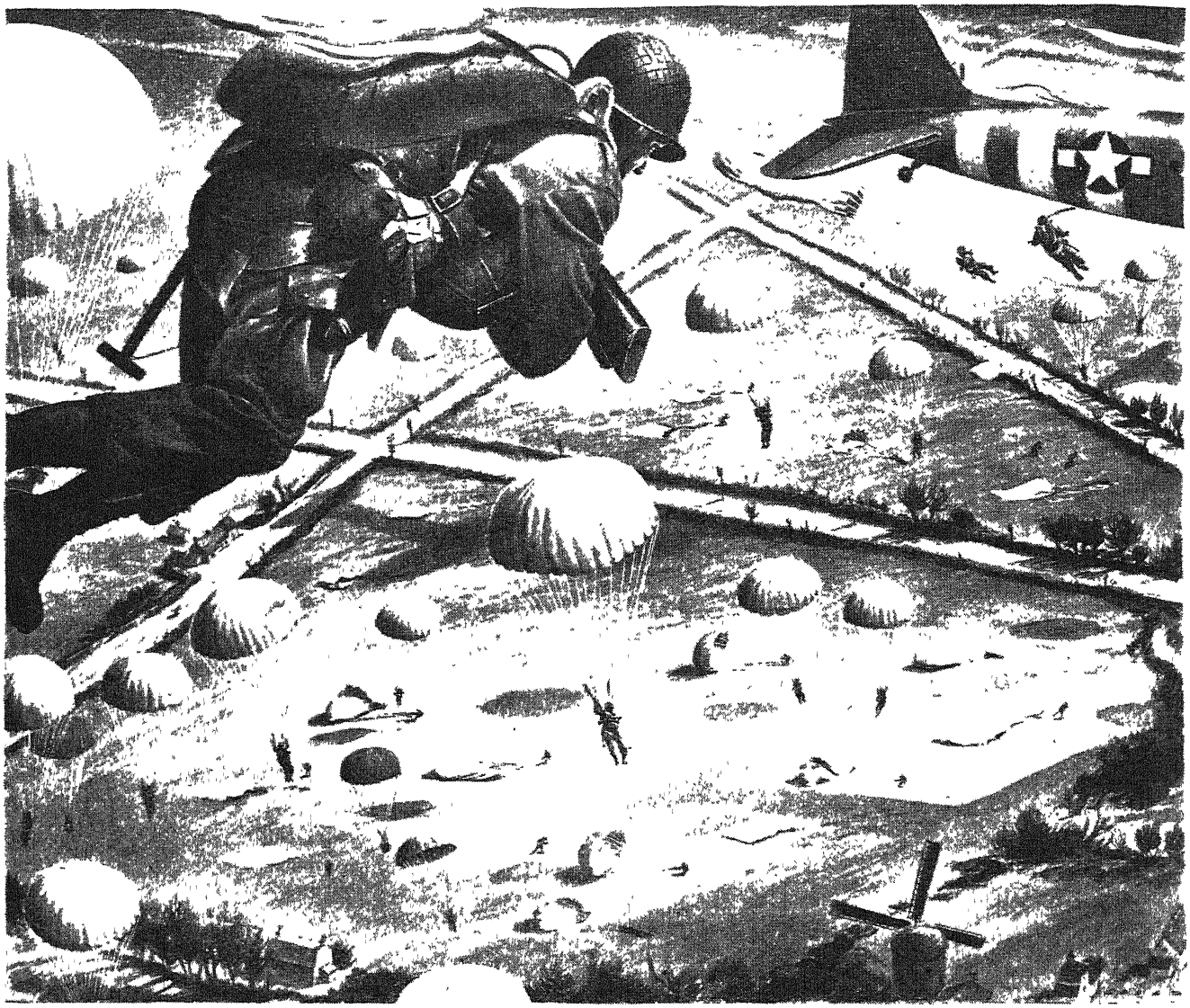
GAS METERS — "Automatic vending mechanism is used in a new gas meter so that a user of gas may purchase a certain amount of gas by simply placing a coin in a receiver, which is so connected to the meter as to allow a certain number of feet of gas to be used for a given amount . . Five quarters can be fed into the apparatus, so that $1.25 worth of gas can be paid for at one time. By this means a person can pay for gas in small installments, rather than wait until the sum accumulates."

What's the Rush?

It's the telephone rush. Every night thousands of service men and women dash to the nearest telephones to talk with families and friends at home. Most of the Long Distance calls from camps and naval stations are crowded into a few short hours.

Many circuits are likely to be crowded at that time and it helps a lot when you "give 7 to 10 to the service men."

BELL TELEPHONE SYSTEM



Over 21 million gallons of gasoline a day to put the

ALLIES ÜBER DEUTSCHLAND

THE American fighting forces aren't the only users of "made in U.S.A." high-octane gasoline. Millions of gallons are going to the British, Russians, Australians, Canadians and our other allies. What's more, this gasoline is all high quality—and practically every gallon is improved with Ethyl fluid.

You can see that as long as the war is on there isn't much hope that civilians will be able to get gasoline unlimited as to quantity and quality. But it won't be long after the fighting is over that gasoline of far higher quality than you've ever had before will be available for running your automobile, truck or bus.

Ultimately, post-war engines will be designed to get more power and economy from this greatly improved post-war gasoline. We of Ethyl look forward to working with the automotive, petroleum and aviation industries in making these hopes come true as quickly as possible . . . but with us, as with you, the winning of the war comes first.

+ + +

ETHYL CORPORATION

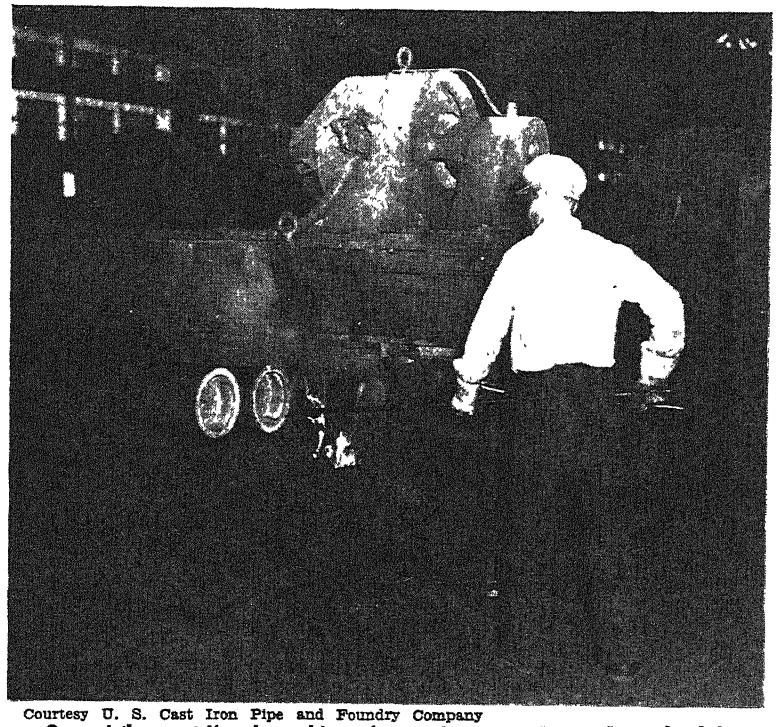
Manufacturer of Ethyl fluid, used by oil companies to improve the antiknock quality of aviation and motor gasoline.

ETHYL — BRAND OF ANTIKNOCK COMPOUND — ETHYL CORPORATION — TRADE MARK REG. U.S. PAT. OFF.

GASOLINE POWERS THE ATTACK—DON'T WASTE A DROP!

METALS IN INDUSTRY

Conducted by FRED P PETERS



Courtesy U. S. Cast Iron Pipe and Foundry Company

One of the centrifugal machines for casting iron pipe and, to the left, some of the centrifugally-cast pipe after removal from the machine

Centrifugal Casting

Assuming an Increasingly Prominent Position in the Metal Industry, this Process Offers Advantages of Economy in Metal and Machining Cost. While its Forte is in the Pipe and Tubing Fields, it can be Applied to the Production of Shapes Other than Cylindrical

By EDWIN F. CONE

Consulting Editor, *Metals and Alloys*

MUCH MORE often today than formerly does the average man hear the term "centrifugal casting." In many instances it means very little to him He knows what a casting usually is—a product made by pouring molten metal into a sand mold, letting it cool to a solid, and separating it from the sand Such castings may be made of gray iron, steel, malleable iron, or a nonferrous metal like brass or aluminum.

Besides the ordinary or conventional casting made in a sand mold there are also die castings, made by forcing a metal into and through a metal die; permanent-mold castings, made by pouring hot metal into a mold, usually metal, which can be used many times as contrasted with a sand mold which can be used only once; and centrifugal castings.

The object of this article is to describe in a general way the centrifugal casting process, confining it largely to castings made of iron or steel, though there are many types of centrifugal castings made of the so-called nonferrous metals such as brass, bronze, or other alloys containing copper, tin, lead, and so forth. One reason for dealing largely with iron and steel in this discussion is that centrifugal iron and particularly steel castings have been increasingly important factors in the war effort and have consequently made rapid progress.

In general a centrifugal casting is one that has been made by pouring molten metal into a rapidly revolving mold This mold is usually made entirely of metal though a sand-lined metal mold is sometimes used. The immediate result of rotation of the mold is to throw the metal to the outside of the mold where it cools first. The size of the casting and its thickness are determined by the amount of metal poured into the revolving mold. The centrifugal process is largely but not entirely confined to pouring cylindrical shapes—castings that have a central axis—like pipes or tubes.

ADVANTAGES—It can readily be seen that a casting so made will have a definite density and solidity, with most of the imperfections—slag, inclusions, and so on—left behind on the inside surface The process also has the decided advantage of speed in production and can be used with molds revolving on either a vertical or a horizontal axis. Such castings can be made with nothing like this rapidity in a conventional sand mold where there is also the disadvantage that slag and dirt more often lodge in the main body or exterior surface of the casting than on the interior surface.

The centrifugal casting process has been further developed so that castings that are not cylindrical can also be made. Often even a sand mold is re-

volved, in order that the liquid metal will be thrown from the center where the metal is first poured. "Centrifuging" is the name used to designate this process.

One of the earliest applications of the centrifugal process for making iron castings in this country was the production of cast iron pipe by the so-called de-Lavaud process. The first work was done by deLavaud (a Brazilian) in Buffalo on a very small scale and in an improvised small machine that produced cast iron pipe about four to six feet long. Not long after this the process was taken up on a large scale by industrial makers of cast iron pipe. A company was soon formed in Canada to produce the iron pipe centrifugally and later the U. S. Cast Iron Pipe and Foundry Company obtained the rights to use the process in the United States. Today that company makes most of its pipe in its several foundries by the deLavaud method.

In the deLavaud process the revolving mold for pipe is made of metal. For some time no little trouble was experienced in the life of these molds. It was later found that a molybdenum alloy steel mold would last much longer. Today such molds are the usual practice.

Because of the chilling effect of pouring hot metal into such a mold it is usually necessary to submit the pipe after casting to a mild heat treatment.

Shortly after the introduction and use of the deLavaud process, a method was developed and perfected for casting pipe in a sand-lined metal mold. The American Cast Iron Pipe Company developed this process—called the "sand-spun" method—and is now producing pipe on a large scale in sand-lined molds. It is safe to say that today a very large percentage, probably over 95 percent, of the cast iron pipe made in the United States is centrifugally cast.

Progress in the application of the centrifugal process to casting molten steel has been markedly accelerated because of the war. Previous to this there were a number of cases where steel products were made centrifugally. A pioneer and progressive organization in this was and still is the Ford Motor Company, in its foundries at Dearborn, Michigan

An outstanding example of Ford's activities in this has been the centrifugal casting of steel gear blanks for automobiles—for the cluster transmission gears and the rear axle gears—formerly made entirely as forgings. The company has now been producing them centrifugally for over six years, and it is now making steel sprocket wheels for tanks by the same process.

METAL SAVINGS—The reason back of this development as well as back of several other metallurgical engineering ones adopted from time to time by Ford engineers, is a cardinal principle of Henry Ford—that whenever it is possible to produce an automobile part so that about 25 percent or more metal could be dispensed with at no sacrifice in quality, such a process should be used. Casting gear blanks centrifugally takes much less metal than making them as forgings and eliminates a large proportion of machining.

In the Ford gear casting process the molds are metal—a low carbon chromium-molybdenum steel. They are set on a vertical axis so that rotation is in a horizontal plane. The speed of rotation (a motor is located underneath the mold) averages from 300 to 400 revolutions per minute. The molten metal is poured into the top center of the flask.

Besides the centrifugally cast sprocket wheel for tanks, an interesting war development of the Ford company is the centrifugal casting of airplane engine cylinder barrels. As in the case of the gear blanks, the barrels were formerly made as forgings. Today many hundreds of these are being produced by the centrifugal casting process. Not only is much metal thus saved but there is also great economy in time since the barrels can be produced faster centrifugally.

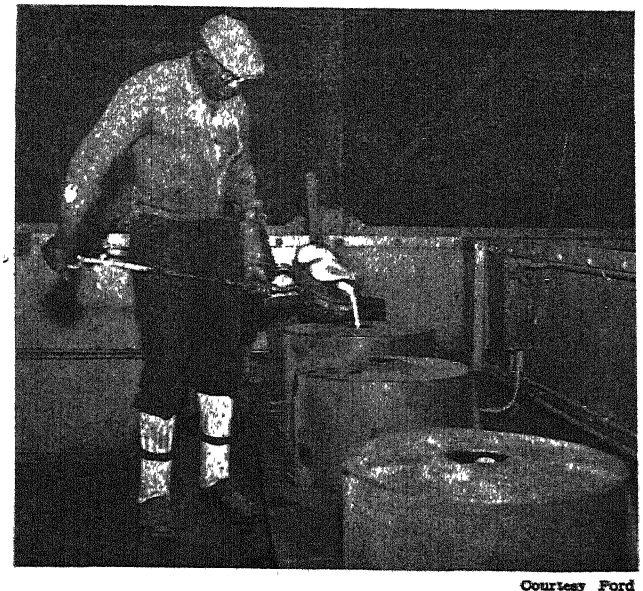
The mold, of a special alloy steel, is made in two sections. The main section is so constructed as to form the upper portion of the barrel. Into this there is inserted and clamped down a smaller piece which forms the other part of the cylinder barrel. Between the two sections is an aperture which forms the flange or protrusion on the side of the barrel In contrast to the mold for gear blanks, this mold revolves on its horizontal axis and the molten metal is poured into the side

Speed in production, saving in time in operating technique, and a product equal if not superior in quality to those produced by forging or any other method are among the advantages claimed for this process, based on the experience of the Ford Motor Company. Besides the gear blanks, the airplane cylinder barrels, and the tank sprocket wheels, this company also produces landing gear axles, solid projectiles, and so on, centrifugally.

Spurred by war conditions, several other companies have taken up the centrifugal casting method for steel Prominent among these is the American Cast Iron Pipe Company, the company responsible for the sand-spun process for iron pipe. This company has installed electric steel melting furnaces and a large number and variety of centrifugal casting machines to make many different products of steel. In over 100 casting machines the company is producing airplane engine cylinder barrels, sheaves and gear blanks, pipe and tubing, track wheels, and so on This company has become a major factor in this branch of the casting industry

Some time ago the Steel Founders Society of America, of Cleveland, made a survey which revealed that there were some 16 companies actually producing centrifugal cast steel products. Besides these there were at least four others which were installing such equipment An editorial in a recent issue of *Metals and Alloys* states that "it is reasonable to calculate that this total of 20 has at least been increased, some say to certainly 30 companies. But the process is not confined to ferrous castings—its use in the non-ferrous field has reached large proportions."

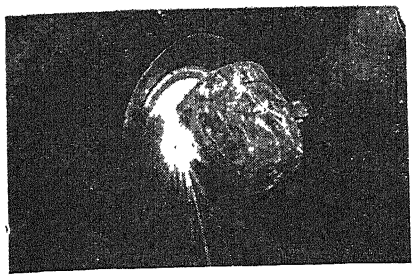
Centrifugally cast steel castings will be more in competition with forgings

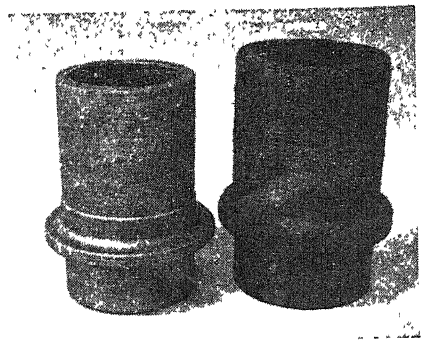


Courtesy Ford Motor Company

Pouring steel into a revolving mold in which gear blanks are centrifugally cast. Mold revolves on vertical axis

Removing a centrifugally cast gear blank from one of the casting machines shown in the illustration at the left





Above: Molten steel being poured into a centrifugal mold for making cast airplane engine cylinder barrels. The mold revolves on its horizontal axis. Right: A centrifugally cast engine barrel weighs only 37 pounds as compared with a weight of 58 pounds for a similar barrel produced by forging methods

and other wrought steel products than with static steel castings. As compared with static castings the economic field for centrifugal castings is somewhat limited. The centrifugal process is not easily adaptable to the economical production of intricate shapes, nor will it be economical for the general run of "jobbing" work.

Compared with steel forgings, centrifugally cast steel castings may be made to closer dimensional tolerances, with consequent reduction in machining cost; the castings entail lower capital investment for production equipment; and they are free from the marked directional properties characteristic of forgings.

Chromium-molybdenum steel castings, centrifugally cast, are being used in place of forgings for engine flywheels, gear blanks, radial cylinder barrels, bomber landing gear parts, and so on. These castings have ultimate tensile strengths higher than 175,000 pounds per square inch and yield strengths in excess of 165,000 pounds per square inch.

It is safe to predict that centrifugal casting will continue to advance and that its present prominent position in the metal industries will be even higher in the post-war era.

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HELMETS

Presented a Challenge to Metal Workers

THE M-1 soldier's helmet, now the standard personal headgear for all American ground forces, is a triumph both of metal product design and of metal-working ingenuity.

Soon after we entered the war the Army sought a redesigned helmet—one that would protect the soldier from missiles from below and give more protection below the ears and at the base of the skull than the hemispherical helmet painfully familiar to the veterans of World War I, and which would also fit the head without rocking and tilting.

Additional requirements were that the weight of the helmet plus its plastic liner must be less than three pounds. It must withstand a .45-caliber bullet fired at point-blank range with a muzzle velocity in excess of 700 foot-seconds, and it must be nonmagnetic to avoid interference with instruments.

The production problems were that the helmet was specified to be Hadfield manganese steel, which, while hard and highly protective, is at the same time one of the toughest steels to draw, especially for the depth of draw required with this helmet.

The problems were finally solved by the McCord Radiator and Manufacturing Company, who now complete the 27 separate operations required to make this helmet, from the first stamping operation to packing, in just 22 minutes. The spectacular feature is that this difficult draw (the new helmet is seven inches deep compared to only four inches for the old "trench helmet") is made in a single press operation.

METAL POWDERS

Now Being Produced in Large Quantities

ALTHOUGH surprisingly large amounts of aluminum and magnesium powders are now manufactured, very little is used in the production of parts by sintering and pressing—the field usually designated as "powder metallurgy."

In an address on aluminum powders before the recent meeting of the Metal Powder Association in New York, A. Galbraith of WPB indicated that some of the post-war uses for aluminum powder might be (a) for producing lightweight parts that would require considerable machining if made by conventional methods, (b) for deoxidizing and grain control of steel melts, (c) in improved paint pigments, (d) as additives in paper manufacturing, (e) as an ingredient of concrete to achieve combinations of light weight and high strength, and (f) in thermit welding and similar applications.

Since the start of the war the production of magnesium powder has expanded 600 times, it was reported by Col. L. J. Pasternak of the Ordnance Department at the same meeting, and post-war markets have not yet been studied. Most of the magnesium powder is now used in incendiary bombs and in flares.

At present flares are produced that yield a million candlepower for a period of one minute. For airplane use the white light of magnesium powder is so glaring that coloring agents are added to reduce it.

DIE CASTING SYSTEM

Makes Use of Newly Developed Technique

THE scope of die casting is being broadened by a new type of machine that makes possible the production of larger, heavier parts from aluminum, magnesium, and copper alloys than were formerly considered possible by die casting, according to F. C. Ziesenheim, writing in *The Iron Age*.

Known as the prefill injection system and applied by Lester-Phoenix, Inc. on its cold-chamber die-casting machine, the method was developed to eliminate porosity, which it does by combining slow injection velocity (as slow as the chilling of the metal and the thickness of the casting will permit) with high final injection pressure on the metal as it chills against the die.

By this "slow-squeeze" method, aluminum, brass, and magnesium die castings can now be produced with strength and densities previously available only in sand or permanent mold castings The National Cash Register Company, for example, is using the system to make 12 carburetor parts originally designed for sand casting. All have unusually heavy gates and are able to pass X-ray and air-pressure inspection tests without trouble.

SPECTROGRAPHY MAKES STRIDES

Is Finding Wider Uses in Routine Analyses

WARTIME experience with the spectrograph has provided abundant evidence that this instrument for rapidly determining the composition of metals will occupy a position of growing importance as a metal-working inspection tool in the post-war period.

One large metal plant, faced with an ordnance program that would tax the personnel and facilities of their materials laboratory far beyond its capacity, installed a spectrograph. A grating-type machine (as distinct from the prism variety) was chosen and within a month the laboratory was running routine spectrographic analyses of iron and steel—controlling four gray iron cupolas, checking incoming forgings and bar stock, and making frequent analyses for control of heat-treating processes.

By using a flat-surface sparking technique this company (The Farmall Works of International Harvester Company) can analyze a singe sample in 15 minutes for eight elements. Nine such samples can be checked in 30 to 45 minutes. Two operators can easily analyze 100 to 150 samples per eight hour day. Total cost will average about 15 cents per sample, or 3 cents per determination.

Does that beat your wet analysis costs? And it's accurate, too, to 3 to 5 percent of the percentage of the element being determined.

They Do Practically Anything

Making Industrial History Today, but Not Making News Headlines, is a Broad Class of Versatile Chemicals, the Ion Exchangers, a New Tool of Amazing Aptitude and a Master of All Trades. With them Industry is Solving Some Problems that have Plagued it, and is Resolving Some Headaches

By JEAN MATER

A FIELD of sugar cane growing tall in the Louisiana sun used to supply enough table sugar for nearly 250,000 cups of coffee. Two years ago a new chemical problem-solver applied for a job in sugar refineries. Sugar chemists put it to work. Now the same field yields table sugar enough to sweeten thousands of additional cups of morning coffee.

Wine is the major objective of vineyards, but buried deep in winery barrels lies a substance essential in making munitions, synthetic silk, and photographic materials The substance is tartaric acid, long familiar to housewives in baking powder. Last year the chemical problem solver which increased table sugar yields entered vineyards; it promises to add several million pounds of tartaric acid to present yearly production.

Aviators met one of these problem solvers for the first time last year in their new sea-water desalters which extract fresh water directly from the sea. The new chemicals have been put to work removing copper impurities from gasoline, and they supply needed minerals to plants growing without soil. The problem solvers help purify vitamins and enzymes, and in gas masks they absorb ammonia fumes.

Jacks of all trades, and masters too—what are these chemical problem solvers?

"Ion exchangers" the chemist calls them, and they are making industrial history. Ion exchangers don't make the news headlines; they are the behind-the-line chemicals working diligently to back their buddies at the front. Penicillin, the sulfa drugs, atabrine, and others equally distinguished rescue us from the death grip of disease. We know them well and intimately. We shall never take ion exchangers to down a fever with dramatic speed but they are nonetheless vitally important, for they are the new tools with which the chemist "trouble shoots" to make the products we daily use more cheaply and more abundant. We may never realize when ion exchangers are working for us.

Ion exchangers are a breed of chemicals with more abilities than we can name—and work with them has just begun. Their aptitude for problem solving is amazingly versatile. They act as scavengers, cleaning up impurities in water and foods. They salvage gold, silver, copper, and other precious metals thrown into mine and factory wastes. They recover nicotine lost in tobacco curing. They separate and purify vitamins and proteins and drugs

Ion exchange itself is a familiar everyday occurence. Recognition of ions themselves dates back over half a century, to 1887 when the Swedish chemist, Svante Arrhenius, defined them as electrically charged wanderers (hence "ions," Greek for wanderers). Ion exchange means simply, as it says,

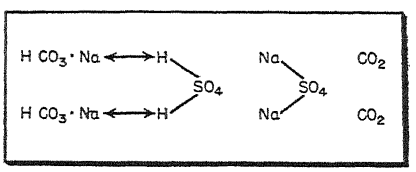


Figure 1: A typical ion exchange

exchange of ions and is the basis for many common phenomena. In using a portable fire extinguisher we exchange the sodium ions in baking soda for hydrogen ions to produce flame-smothering carbon dioxide. The hydrogen ions are supplied by the bottle of sulfuric acid released when the fire extinguisher is inverted. Figure 1 shows how the chemist pictures the exchange of ions in fire extinguishing: baking soda and sulfuric acid produce sodium sulfate and carbon dioxide gas.

Baking powders work by ion exchange. Baking powders are a mixture of an acid and baking soda. Exchanging the hydrogen ions in the cream of tartar —or alum or whatever the baking acid used—for the sodium ions donated by the baking soda produces enough carbon dioxide to make the cake rise. The curd formed in lathering soap in hard water is an ion exchange process. Soap is a mixture of the sodium salts of fatty acids. Hard water contains calcium salts When we try to lather in hard water the calcium salts exchange places with the sodium in the soap, depositing a curd on the wash basin. Ion exchange is at work in our blood stream 24 hours a day. Our blood acidity remains constant despite all the acids added to it by the process of living because it contains a so-called "alkali reserve"—bases such as sodium bicarbonate, sodium phosphate, and other sodium salts upon which the blood can draw to neutralize acids. When we exercise, our muscles throw lactic acid (the acid in sour milk) into the blood stream. The sodium ions supplied by the "alkali reserve" exchange places with the acid ions to form harmless sodium lactate and so preserve our blood stream neutrality.

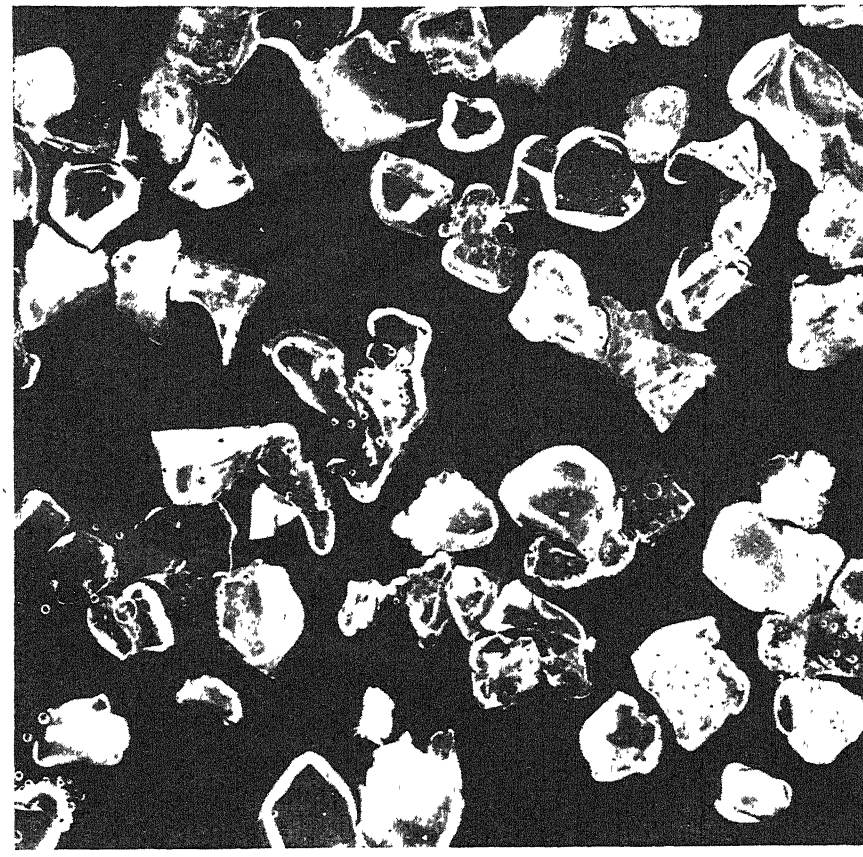
THEY ITCH TO SWAP—Fire extinguishing and baking and preserving our internal neutrality are all ion exchange phenomena The industrial problem-solving ion exchangers work exactly the same way—except that they are definite compounds which devote their chemical lives solely to exchanging ions with whatever other compound would like to swap. Usually they are of no use in themselves; their claim to fame lies in their generosity with the ions in their possession Ion exchangers is a broad term—like sulfa drugs—used to denote many similar compounds. Some exchangers will swap for metallic ions—such as calcium, magnesium, copper, and the rest of their family. These are cation exchangers (cation because in electrolysis the metallic ions are drawn to the cathode). Other exchangers adsorb acids on their surfaces. They are the anion exchangers (because the acids go to the anode). Some cation exchangers are old and familiar. Natural and synthetic zeolites—"greensands" being the natural type—have long been used for water softening in the classical Permutit process. But the "greensands" and zeolites are limited in use almost entirely to water conditioning. It is the new stable, synthetic cation exchangers which are doing the chemical tricks. These come from two sources Treat coal, lignite, or peat with an organic sulfur compound and we produce "carbonaceous zeolites," one class of ion exchangers Other cation exchangers are plastics prepared from phenol-formaldehyde resins.

How plastics became ion exchangers is an interesting story. In 1935 two Englishmen, Basil Albert Adams and Eric Leighton Holmes, of the British Department of Scientific and Industrial Research, had a hunch about a team of oxygen and hydrogen, called the *hy-*

droxyl group—pictured OH—in Bakelite, a phenol-formaldehyde resin. They reasoned that since the hydroxyl group was not involved in forming Bakelite it should be free for ion exchanging

As the chemist sees it, Bakelite is a chain-like linking of phenol and formaldehyde In chemical pictures, the wedding takes place with two molecules of phenol attaching themselves to formaldehyde (Figure 2). The two *hydroxyl* groups sit idly by during the reaction. On these two hydroxyl groups Adams and Holmes counted for ion exchange. Experiments proved their hunch good. The discovery opened up a new field for plastics and unexpected new vistas for chemists. Previously Bakelite and other plastics were judged solely on their capabilities as materials for fountain pens and telephones and steering wheels Now they could be re-evaluated as chemical compounds with more uses than any chemist had dared dream. The advent of the new resins and the carbonaceous zeolites plunged ion exchangers into a whirlwind of industrial activity, an event with almost startling repercussions in expanding the sphere of activities of many companies. The Resinous Products and Chemical Company, for example, was making phenol formaldehyde resins for cementing plywoods when ion exchangers poked their head in the door. Now with ion exchangers the company's chemists find themselves investigating vineyard wastes and metal recovery in mining Other companies, such as Permutit and Infilco—who have been using the older zeolites for conditioning water—have become involved in industries far removed from water. The Permutit Company developed the first carbonaceous zeolite to improve water treatment, but the zeolites led their creators into new worlds. This is a type of industrial expansion becoming more common as research interrelates chemistry.

HOW THEY WORK—Here's how the cation exchangers work. In softening water, where we want to remove calcium—or it might be magnesium which also hardens water—we add a sodium exchanger. The sodium exchanger takes up the calcium and leaves sodium sulfate in the water Sodium sulfate is all right; it does not leave a sticky scum with soap Now, all we need do is get rid of the sodium sulfate in the water and we have water with no ions at all—in other words, distilled water. And that's where the anion adsorbents or exchangers come in Anion exchangers



Magnified granules of Decalso zeolite

are resins of complex composition which have the power of adsorbing on their surface acids, thereby removing them from the water. To produce synthetic "distilled" water we start with a hydrogen exchanger and form an acid like sulfuric acid instead of sodium sulfate. An acid adsorbent next lifts the sulfuric acid bodily from the water, leaving water with no ions Thus ion exchangers "distill" water chemically The ion exchange method for producing distilled water often gives even purer water than mechanical distillation. Water distilled with ion exchangers is playing an important war role in preparing the large amounts of very pure water needed for synthetic rubber, pure chemicals, and drugs. When we remember that up till now distillation has been the one method of producing very pure water we realize that ion exchanged pure water is a history-making achievement. Now, for the first time, it is possible to make more "distilled" water more quickly than ever before thought possible, and at as low as one quarter the cost. Synthetic "distilled" water is quite a feather in the ion exchanger cap.

Carrying our reasoning further: if we can remove all the ions from water why not desalt sea water to fresh drinking water? This appealing idea has caught many fancies and has been the subject of much research. For, despite all the advances of modern science, our aviators forced down at sea found that "water, water everywhere and not a drop to drink" was as true as the day the Ancient Mariner first said it. But all attempts to use the standard ion exchange process on sea water were fruitless. Each man would need such a large quantity of exchangers that the idea was entirely impractical. It looked hopeless until the Permutit Company came along with its widely heralded sea water desalter, an ion exchanging device which removes both cations and anions—the sodium and the chlorine in salt—at the same time. How, must remain another military secret for the duration.

However, standard ion exchangers do some interesting desalting tricks on brackish waters which periodically are a nuisance to industrial plants in certain sections of the country. The Delaware River, for example, becomes salty during droughts and low water periods. Along the industry-jammed span from Philadelphia to Wilmington the salt content has often been high enough to hinder boiler plant operations and in some cases even to force a boiler plant shut down. Ion exchangers have nipped this source of trouble in the bud.

An attractive fact about ion exchangers is their ability to be regenerated. That they have exchanged all their sodium for calcium, or adsorbed

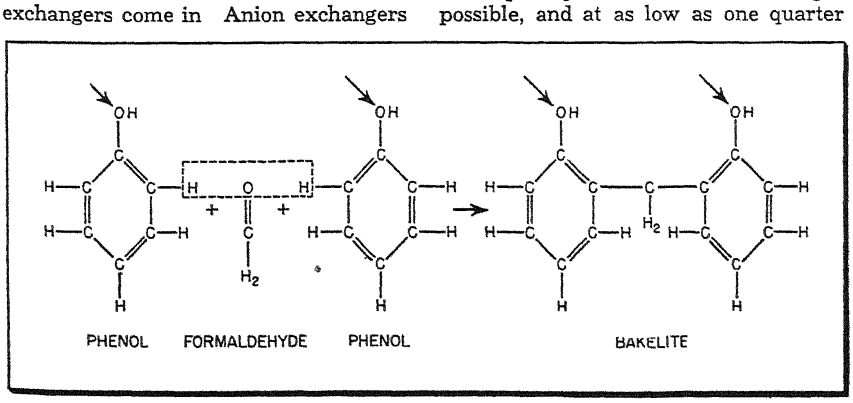
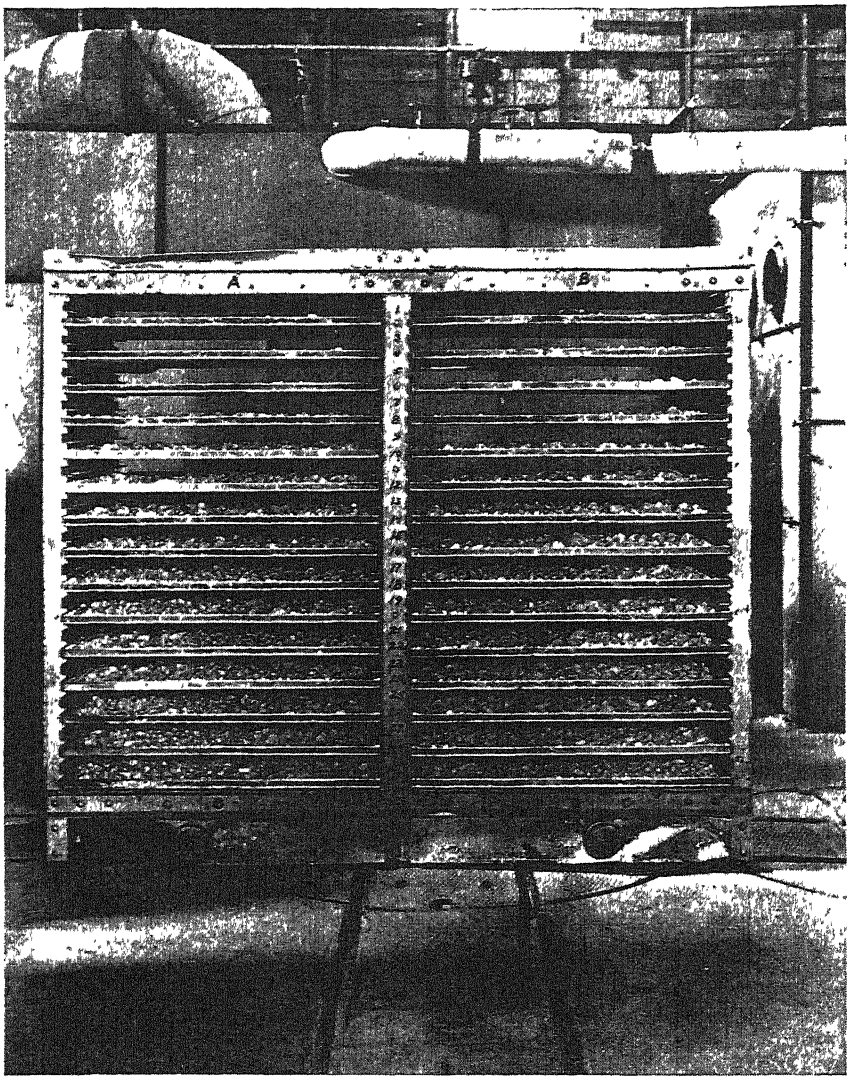


Figure 2: Structural formula for the wedding that produces Bakelite



In the manufacture of synthetic zeolites, the solutions of aluminum and silica compounds are combined to form a gel, which is then dried and broken into grains

all the acids they can hold, does not mean that they are used up and done with. Simply passing a solution of common table salt over the exchanger washes out the calcium and brings sodium back to the fold. The exchangers are then ready to remove more calcium. To regenerate acid adsorbers it is necessary only to clean them with ordinary washing soda. The regenerative ability of the exchangers cuts the cost of their use almost to the initial cost of the operating equipment.

To date, the largest application of ion exchangers has been to water treatment —softening water for breweries, paper and textile mills, bottling companies, power plants, and other industries. Soft water is so essential to some products that process plants usually locate in areas where the water is good. That is why so many textile and paper mills are in the soft-water districts of New England and why so many breweries are located in New York City and Newark. The water in these cities is soft enough so that it requires very little further treatment. With excellent water conditioning at hand, location near good water will in time probably become secondary.

But ion exchangers promise to be most valuable as problem solvers in other fields. One of the most difficult industrial problems ion exchangers have solved is purification. Ion exchangers are perfect scavengers for cleaning up metallic impurities. A patent has been issued for the application of ion exchangers to freeing gelatin from metallic ions. Absolutely pure gelatin is essential for photographic and medicinal use. Formaldehyde must be free of acids when it is used in making plastics. Since most formaldehyde comes today from methyl alcohol by a process which also yields a very small amount of acid, it is difficult to obtain acid-free formaldehyde. The acid could be neutralized with a base, but this is a tedious process and the resulting salts produced are as objectionable as the acid itself. Activated carbon will remove the acid but that is a cumbersome and expensive method. An acid adsorbent simply lifts the acid out of the formaldehyde, purifying almost immediately. After the war we may expect the ion exchange technique to purify the solvents used for dry cleaning our clothes. Ion exchangers have performed heroic feats in completely freeing organic acids, glycerol, wines, and enzymes from any traces of harmful calcium, iron, copper, or lead. These metals are difficult to remove with any other method, if indeed older methods remove them at all.

Ion exchangers have considerably enhanced their reputation in the last few years by their unique salvaging abilities. Ion exchangers are valuable in recovering precious metals from wastes. Copper has been reclaimed from brass mill pickling waste and from rayon waste. Leftovers which used to be dumped into local streams, polluting and fouling the waters, are now reexamined for possible reclaim value Removal of metals from waste water is a favor to the community and profitable to the remover as well, for precious metals recovered more than repay the cost of salvaging. Ion exchangers also have a talent for rescuing valuable organic chemicals from an otherwise useless end. Tartaric acid reclaim has been mentioned. Ion exchangers save pectin—the familiar jellying agent found on kitchen shelves and recently proclaimed a substitute for blood plasma in some cases—from grapefruit and orange rinds. Citrus fruits have always been rich in pectin but it has been so difficult to recover that the attempt was considered useless. Ion exchangers do the job in a few simple steps. In curing tobacco much nicotine is lost to waste. Nicotine, as every gardener knows, is a valuable insecticide. Ion exchangers can rescue nicotine from the waste and can put it to work killing insects. In time ion exchangers should cut the cost of nicotine to consumers Reclaiming possibilities are legion and many laboratories throughout the country are busily delving into others destined to become important.

EVEN VITAMINS—Ion exchangers scored a victory in the large-scale production of essential amino proteins such as arginine, histidine, and lysine—three leaders of the protein family that make up to our tissues the wear and tear of daily living. Ion exchangers have stepped into our vitamin pills too. Thiamine, one of the B vitamins, occurs with riboflavin, another member of the B complexes. These two cling tightly to each other and are extremely difficult to pry apart. But when they run through a bed of ion exchangers, thiamine divorces riboflavin and hugs the ion exchangers. Riboflavin passes indifferently by. With this technique thiamine is successfully recovered from rice bran extracts. Solutions containing thiamine and riboflavin passing through a five-inch-thick bed of ion exchangers at the speed of seven gallons a minute are almost completely separated.

It is almost 100 years since the English chemist, J. T. Way, made the first observations on ion exchange. Way studied the exchange of ions in soils. Today the branch of chemistry Way helped initiate has given birth to ion exchangers which are used in growing plants without soil In soiless growth cation exchangers hold sodium, potassium, calcium, and other mineral ions in tow. Anion adsorbers are bound to the important phosphates, carbonates and sulfates. Put the two together in water, add a plant and we have a balanced system. When the plant needs a mineral ion the exchangers simply give it up.

What About the Gas Turbine?

Will these Simple and Potentially Efficient Power Plants Out-Mode Steam, Gasoline, and Diesel Engines Overnight? What are the Fundamental Reasons Why the Gas Turbine, Based on Four Centuries of Thinking, is Only Now Emerging from the Dream Stage? A Searching Analysis Gives the Answers

THE GAS TURBINE, one of the oldest ideas for power plants, is just emerging from the dream stage and poking its head up into reality.

The gas turbine idea really is old. Leonardo da Vinci had it all worked out about when Columbus first set foot on the western hemisphere. Bishop William wrote the whole thing up while our soldiers starved at Valley Forge, John Barber, an Englishman, took out the first gas turbine patent in 1791. Since then the correct answer to the question "who invented the gas turbine?" almost has been "who didn't?" Yet with almost every engineer and his brother thinking about it, the gas turbine got nowhere while the reciprocating steam engine, the gasoline engine, the steam turbine, and the Diesel brought power generation to where it is today.

Two problems—high temperatures and air compressor efficiencies—held the gas turbine back.

Lick those two, and the gas turbine becomes the simplest, most efficient, most desirable power-plant on earth. All there is to it is rapid combustion of fuel, confining the gases of combustion within a pipe so that they can flow only to the point of work, and running those gases through turbine blading to generate power from their expansion. The air compressor in the gas turbine (Figure 1) serves the same primary purpose as the supercharger on a gasoline engine; it supplies the necessary volume of air for combustion.

This utter simplicity of the gas turbine idea has tantalized inventors for five centuries. Yet if they let gases at combustion temperatures go to the turbines, then the turbine blades melted like lighted candles. If they increased the load on the compressor and supplied excess air to the combustor—the obvious way to cool down the gases—they could not get a turbine-compressor combination efficient enough so that the turbine would drive its own compressor, let alone supply useful power.

Hard at work on all these same problems right now are gangs of practical machinists, "long-haired" researchers, mechanical draftsmen, metallurgists, college professors. Back of them, and spending money so fast that a million dollars will not buy a white chip, are outfits like Westinghouse, General Electric, Allis Chalmers, Worthington Pump, DeLaval, Brown Boveri, Northrup Aviation, the United States Army, and the United States Navy. And working just as hard are a horde of little fellows. With all the basic ideas so old, the patent situation of the gas turbine is as wide open as Grand Central Station.

A high percentage of the researchers working for the big companies were brought up on the steam turbine and thus they are old dogs trying to learn a new trick. Some of the jackpots therefore may go to "fresh minds" who are banging away in the backs of their garages

WHERE IT STANDS—Today's researchers can solve problems which beat them yesterday, because they have so many other developments to borrow from. They are getting air-compressor ideas from 40 years of steam turbine experience (the compressor generally used is a turbine in reverse), intricate blade shapes from the precision castings industry, high-temperature-high-stress blade metals from steam-turbine and high-speed metal cutting tool practice, combustion knowledge from oil burners, fuel performance data from the airplane engine and the Diesel. Old timers lacked these resources; had to fumble in the dark.

Exactly how far gas-turbine researchers are getting in a practical way, these people are not yet telling. An interviewer cannot probe beneath the skin of this subject anywhere without poking into a military secret of some kind

A few of the facts, however, can be told without violating confidences. For example

Gas turbines are supplying compressed air for pressure fired steam boilers. Waste gases from these boilers are at 800 to 900 degrees, Fahrenheit; they can be led through turbines to generate power and compress the air to the 35 pounds pressure at which it is fed to the furnaces.

Gas turbines make excellent airplane engines, either to turn propellers or to compress the air required for combustion in jet-propulsion power plants.

Gas turbines have been tried successfully on railroad locomotives by Brown Boveri in Switzerland and studied by General Electric in the United States.

But if the gas-turbine men cannot yet tell all the things they are doing, they at least can tell some of the things that they know they can do in the near future.

First of all, they can enter engine markets which are not now satisfactorily supplied. There is no inherent

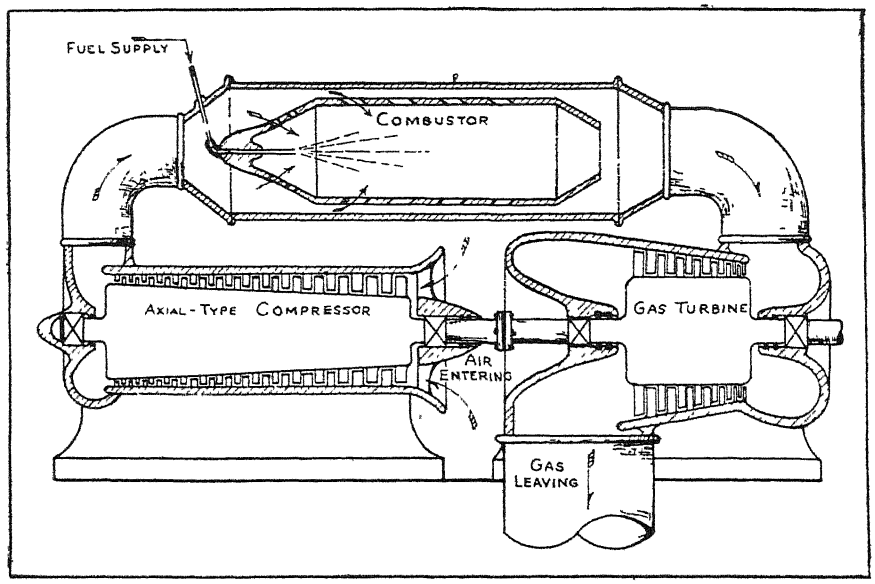


Figure 1: Major elements of the gas turbine cycle

limitation on gas turbine size; no reason why a gas turbine cannot be made as small as a thimble or as big as a warehouse. But with reciprocating engines for airplanes already developed and working well up to the 3000 horsepower range, why not leave that range alone and start on the 4000-and-up behemoths needed for the skyways of the future? Working that way, the gas-turbine builders can get a lot more of their development money out of aircraft builders than they would if they were to aim at markets for which there already are satisfactory power plants.

The same point applies to railroads, with the difference that a simple gas turbine has 16 percent thermal efficiency compared to about 8 percent for ordinary reciprocating steam locomotives, and might pay for its development out of fuel and weight savings in the smaller sizes. But engine sizes are going bigger and bigger, with 4000 horsepower units in use and 6000 horsepower ones being built. The 4000 horsepower Diesel-electric job is made up of two 2000 horsepower units with a total weight of 506,000 pounds. With only 364,000 pounds—a saving of 66 tons—a gas-turbine locomotive could put out 4500 horsepower.

IN MOTOR VEHICLES—Your automobile engine has up to 25 percent thermal efficiency, and a gas turbine at a nominal operating temperature of 1200 degrees, Fahrenheit, ought to have at least 39 percent, but the reciprocating engine has a tight enough hold on this market so that no automobile maker is planning to put a gas turbine under the hood of your car—or, at least, if anyone is he has not said anything about it. But the big overland trucks with their trains of trailers could use that extra flow of smoother power with less engine weight and no water needed for radiators or anything else, and some gas turbine maker is likely to give it to them.

For ship propulsion, the gas turbine can save space and weight, and get rid of the boiler and steam condenser—the condenser being the pest of the engine room, with its changing performance as sea temperature changes, and its corrosion, clogging, and leaking problems But nobody has yet come out with a reversible gas turbine (there is no reason why somebody should not) and the gas turbine would have to have electric drive or else mechanical gearing for stopping the ship and backing her up, or be connected to a variable pitch-reversible pitch propeller. Furthermore, the main drive gas turbine would not run the ship auxiliaries—the winches and steering engines and all—unless some new type were to use the 600 degrees, Fahrenheit, gas exhaust to generate steam for this or to work some other stunt.

Factories and public utility central stations have fewer unsolved power problems, therefore offer less of an immediate market to the gas turbine There would be a big demand here if the gas turbine could run on coal, but right now it needs high grade ash-free Diesel fuel. A 20,000 kilowatt simple cycle gas turbine might be helpful for remote unattended or stand-by service; it would start up in a few seconds where other plants take minutes.

Airplanes offer juicy prospects. The fact that the simple cycle gas turbine could be switched on by the pilot and be ready for the take off by the time he had glanced at his instruments, could save hundreds of military planes which now are destroyed on the ground by enemy action And in peacetime, too, this quick getaway would show a profit by cutting out warm-up time costs and by letting extra ships be ready quickly when needed for heavy traffic. Add to this the savings in weight and space, the lack of need for air cooling or chemical cooling of the engine, and you have something. That is, you have something when the turbine designers can get away from "speed at any price" military needs and spend some time on commercial plane power plants.

One development engineer believes that markets for the gas turbine will be attacked in this order:

1. Airplane
2. Airplane locomotive
3. Chemical industries and oil refineries
4. Ships
5. Utilities
6. Trucks
7. Factories.

He was, of course, speaking only for his own company. He did not know what his 16 bigger and 160 smaller competitors have in mind. He could not speak for an outfit like Westinghouse, which is so deep in war experimental work that its engineers have to clamp the censorship lid on dramatic developments while its publicity men gnaw their finger-nails in pure frustration. But behind his views was some solid reasoning. These markets will probably be ready for the gas turbine in the same sequence as development work will progress.

The first development is the simple cycle. This is low in thermal efficiency At the nominal 1200 degrees, Fahrenheit, operating temperature at the turbine blades, some 2.95 out of every 3 95 horsepower it develops is used to run the air compressor About one fourth of the turbine power then can be used at the coupling. Nevertheless, its complete simplicity, its savings in weight, space, piping, electrical devices, and mechanical gadgets, makes the simple cycle attractive for airplanes. This puts the aircraft market first in line.

The simple cycle could be used on a railway locomotive, too. Its increased thermal efficiency over the reciprocating steam engine would pay its way. But locomotives must supply more than power; trains need heat. And this gives the development engineers a chance to go a little bit further.

Intercooling can be applied to the compressor to take heat out of the compressed air and thus increase the volume of air delivered at the same pressure. This is a common practice with air compressors everywhere. It requires cooling water which enters the compressor cold and comes out hot. In an airplane this would be something of a

How One Engineer Rates the Thermal Efficiencies Of Power Plants

Type of Plant	Ordinary Thermal Efficiency
Steam Locomotive	8%
Gas Turbine (at 800-900 degrees)	16%
Automobile Gasoline Engine	20-25%
Marine Steam Turbine (6500 horsepower plant as used in C-2 or AP-2 ships)	25%
Central Station Steam Plant (25,000 to 75,000 kilowatts)	30-33%
Gas Turbine (at 1200 degrees)	39%
Mercury Cycle Steam Plant	40%
Diesel Engine	36-42%
Gas Turbine (at 2000 degrees)	57.5%

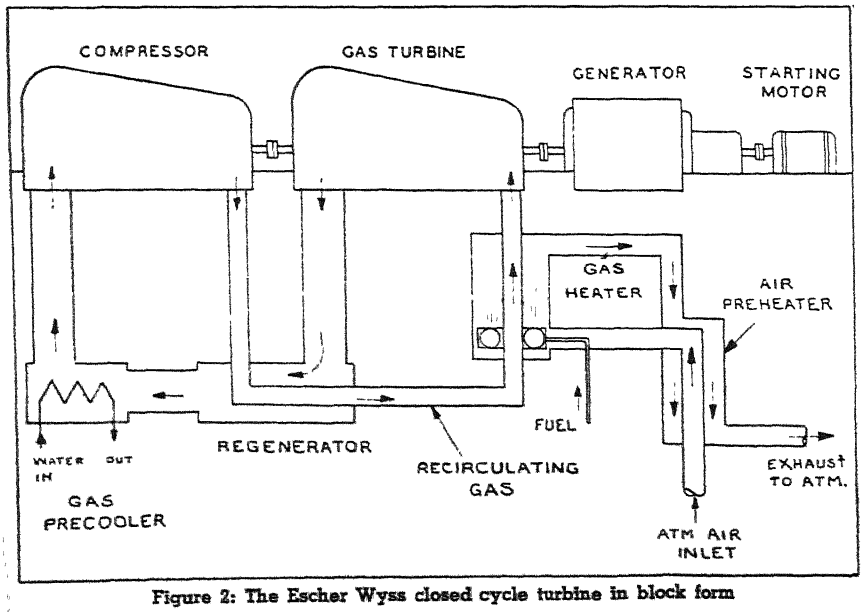


Figure 2: The Escher Wyss closed cycle turbine in block form

nuisance, but a railway train can use hot water. One stage of intercooling can reduce the work of the compressor 15 percent and make that much more power available at the draw bar.

The locomotive can make use of regenerative heat, too. This means taking heat from the 600 degrees, Fahrenheit, exhaust of the turbine, and using it to warm up the combustion air entering the combustor. Every bit of heat applied here means just that much saving of fuel But exhaust heat can be used further in a waste heat boiler. If separately fired, this boiler could make steam for starting the turbine. No gas turbine announced so far is self-starting, that is another of the developments which may come any minute.

Reheating is practical in a locomotive turbine. Reheating is helpful because as the gas passes through the turbine it cools down and loses power so that the exhaust end of the turbine has less power than the inlet end If fuel is burned in the cooled gas—and this is easy to do, as the gas contains some 85 percent of excess air to cool it down from the combustion temperature and save the turbine blades—then the temperature of the gas can be kept nearly uniform throughout the turbine and the power of the same sized turbine can be greatly raised.

With all these gains in efficiency at his hand, the locomotive gas turbine designer can do either of two things. He can keep his working temperature at the blades at 1200 degrees, Fahrenheit, or higher. Or he can reduce his operating temperatures and save his turbine blading.

INCREASING EFFICIENCY—Compare the two procedures. A simple cycle gas turbine at 1200 degrees might run at 20.2 percent thermal efficiency. Add intercooling, reheating, and regenerating, and the efficiency goes up to 32.2 percent This means a great saving of space and weight for the same draw bar pulling ability. But cut down the temperature to 800 degrees and about 16 percent thermal efficiency may be left—these figures change with design features.

Metals which will stand up at 750 to 800 degrees, Fahrenheit, are much easier to find than those which will take 1200 degrees. The obvious answer is a locomotive which runs at 800 degrees or more for ordinary pulling but has the higher temperatures and efficiencies on tap for short-time use on steep grades.

When a locomotive gas turbine is developed that far, it has everything that the open cycle can have for any application. Chemical plants and oil refineries could use such a turbine; they need the power and the waste heat, and in many cases—especially in refineries—they have waste gases which could be used for fuel

The next step beyond the open cycle is the closed cycle turbine.

Here is the difference. In the open cycle, the products of combustion go from the combustor, through the turbine, and out of the exhaust. But in the closed cycle the products of combustion either do not go through the turbine at all, or if they do go through it then they do not go immediately through the exhaust

In one closed cycle, the Escher Wyss (Figure 2), the gases from the combustor are used to heat a second gas as if it were water in a boiler. Hydrogen makes a good second gas for this, it has 6 8 times the thermal conductivity of air and 14 times the specific heat, and can pick up and use the combustion heat that much better. The second gas gains in pressure as it is heated, but loses pressure when delivering power through the turbine. After leaving the turbine it therefore flows through a compressor which increases its pressure, then goes to the combustor gas heating chamber to pick up more heat and pressure, and the cycle is repeated.

Westinghouse has a closed cycle machine in which the products of combustion pass through the turbine. Instead of being exhausted, these hot gases then go on into a compressor. They still contain 85 percent of excess air and plenty of heat units. Enough make-up air is added by a second and independent compressor to keep the system in balance

The advantage of the closed system is that it gets the same power out of much smaller equipment. In a simple cycle turbine the inlet pressure is less than 100 pounds per square inch absolute when working at 1200 degrees, Fahrenheit. In a closed cycle the absolute pressure can be much higher. And when that pressure goes up the size of the equipment can come down at the same rate; increase the absolute pressure five times and the size can be reduced by 80 percent.

Savings in size like this seem unimportant until the capacity of the equipment reaches 7500 kilowatts or more Therefore most of the closed cycle systems exist on drafting boards and in experimental laboratories. Very few are actually at work.

But the notion that closed cycles are for big sizes only is another of those ideas which may get knocked into a cocked hat at any minute. Westinghouse, General Electric, and others have been generous in publicizing performance figures, but they could not talk about all they have even if they wanted to.

The gas turbine is working, enormous sums are being spent to make it work better, its temperature and efficiency problems are being solved, and it is going to make a big difference in the entire power generation field. But nobody really knows what improvements in it are coming next.

Sequence In Which Gas Turbine Fuel Problems Should be Conquered

1. It uses high grade ash-free Diesel oil now.
2. Next should be light-bodied fuel oil.
3. Then Bunker C fuel oil.
4. Crude petroleum.
5. Fuel oil with colloidal or peptized coal mixture.
6. Pulverized coal.
7. Solid coal.

(This is the normal sequence of progress. But somebody may come out with a solid coal burning gas turbine to-morrow.)

Basic Facts About Gas Turbines

1. After 500 years the turbines are working economically.
2. Basic patents are wide open. Anybody can get into the game.
3. Any type of turbine can be used; radial flow, axial flow, tangential, reaction, single stage, compounded, or what have you.
4. The turbine can run its own air compressor when both have about 65 percent efficiency. Turbines of 84 percent and compressors of 85 percent efficiency are in use; therefore the turbine delivers power.
5. A good many of the high temperature problems have not been solved.
6. Present fuels are limited to high grade ash-free Diesel oils.

SLIME CONTROL

Aided by Dehumidification of Air in Dams

DEHUMIDIFICATION of air has been found effective in reducing slime accumulations in the inspection galleries of large dams. This new use of air conditioning, developed in connection with the operation and maintenance of large dams and power plants, is reported by S. O. Harper, chief engineer of the Bureau of Reclamation in a recent issue of *Engineering News-Record.*

During the humid season of the year, the normal temperatures of the galleries and of mechanical and electrical equipment within the dams are appreciably below the dew-point temperature of the outside air. This leads to condensation of moisture on the walls and galleries as well as on the mechanical and electrical equipment. Moisture accelerates the growth of microscopic organisms and the formation of slime upon the walls of the galleries, causing rapid deterioration of paint film and corrosion of metal surfaces. Also, moisture permeates electrical installations and causes breakdowns.

One installation of equipment for dehumidification purposes is now being made at the Marshall Ford Dam in Texas, and a second is projected for the Grand Coulee Dam in Washington.

Electronics in Transportation

Radio and Radar Equipment Developed for Military Use Will be Available After the War to Expedite Routing of Mobile Units in the Transportation Industry. Even Manufacturing Plants can Benefit from Two-Way Radiophone Service, Television, and Almost-as-Fast Facsimile Transmission

With millions of man-hours and dollars being poured into electronic research during these war years, and with greatly expanded factory facilities now fully tooled up to produce the new products resulting from this research, the inevitably high experimental and tooling costs of new electronic developments will, in most cases, have been written entirely off the books by the end of the war. Except, then, for minor post-war conversion expenses, war-created electronic developments can be manufactured after the war at production costs unpadded by high research expenses.

Probably the most glamorous electronic gadget so far revealed to the public is radar. Installed in military planes, ships, and ground locations, it detects approaching enemy aircraft and surface vessels at night or in fog, far beyond the capabilities of human vision, and automatically aims guns to hit those enemy targets miles away. To the industrialist, such uses as railroad collision prevention, guidance of marine traffic at sea during darkness and fog, and detection of obstacles in the path of aircraft flying blind mean greatly increased speed of transportation of their raw materials, supplies, and finished products, with simultaneously reduced loss risks.

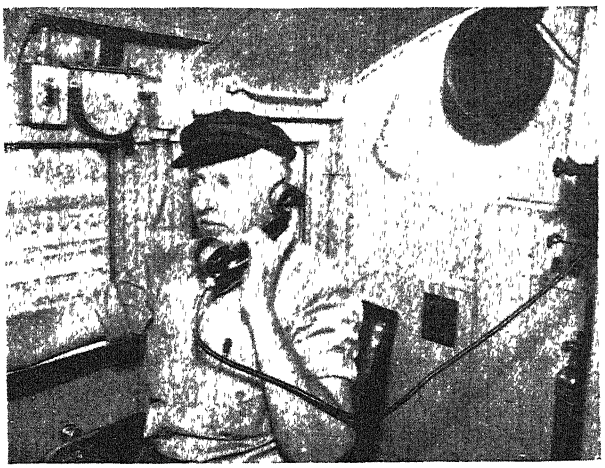
Although electronic developments now under restrictions of military secrecy must wait until after the war for industrial utilization, considerable progress has already been attained in the case of some newly improved equipment, notably two-way radiophone service between mobile units and between mobile units and one or more fixed stations. As examples, in recent months several railroads have installed various types of equipment, plans have been set up in Cleveland for routing cabs by radio, and ship-to-shore radiotelephone service has greatly reduced Great Lakes shipping losses. Street railway lines, buses, truck delivery services, and isolated factory facilities are now in a position to profit from radiophone service based upon commercial utilization of highly effective military handi-talkies and walkie-talkies utilizing frequently-modulation principles, just as have police, fire, ambulance, forest protection, and similar public services.

In applying radio and other electronic signalling principles as a means of increasing efficiency and safety in the railroad field, engineers have developed a number of practicable train communicating methods. Although each method employs electronic tubes, the various modes of operation differ widely and have individual advantages and disadvantages under various conditions. Technically these methods can be divided into three groups: space radio systems; induction radio systems; and rail carrier telephone systems.

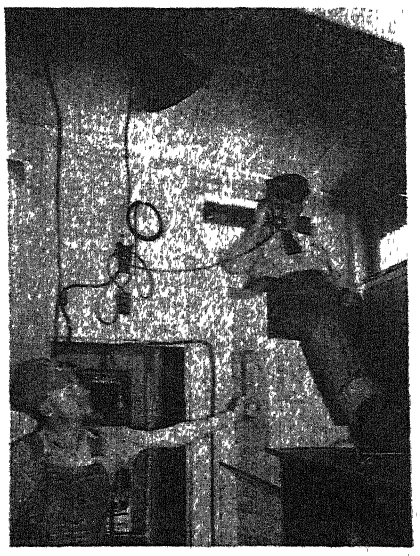
Space radio systems can use either conventional amplitude modulation or the newer frequency modulation principle, both of which provide flexible and versatile means of train communication. Space radio systems will continue to function with full efficiency when wayside wires or tracks are damaged by storms, floods, wrecks, or other causes since they do not depend upon metallic wire signalling circuits as do the other two systems. This is a highly desirable feature since maintenance of positive communications along railroad rights-of-way is most urgently needed during such emergencies.

Instructions given by radiotelephone to an engineman must be followed in minute detail unless they are countermanded. Should central-station equipment fail after issuance of orders, or should locomotive receiving apparatus become inoperative for any reason, the engineman, if not advised of such failure, would proceed to follow the original instructions while in ignorance of attempts by the dispatcher to change these orders. This might cause trouble.

In the railroad system of one ordnance plant, precautions are taken by transmitting carrier-wave energy from the central station at periodic intervals by means of an automatic pulsing device which momentarily keys the transmitter at predetermined intervals. Concurrently with emission of the carrier, a tone signal is impressed on the input circuit of the transmitter. In locomotive cabs, the recurrent pulse signal actuates a check light, while the tone signal is reproduced by the cab loudspeaker.



Right: The engineman on a Seaboard Air Line Railway train uses the radiotelephone installed in his cab to communicate with the conductor in the caboose of a Diesel-electric freight train



Left: In the caboose the conductor uses the radiotelephone as conveniently as he would the ordinary wire telephone in his own home

The frequency of the tone signal is such that it may be heard above normal background noise within a cab.

A system of this general type provides a check on overall operation of the radio control system. In event of failure of the central-station transmitter, or any portion of the locomotive receiver, including the loudspeaker, the audio-visual signals are not repeated in the cab, thereby warning the engineman that the radio system is inoperative.

Protective radio control techniques are of particular value during freight classifying operations when a locomotive is pushing a long string of cars over a "hump" where freight cars are uncoupled, usually one at a time, and allowed to coast down to a particular track in the classification yard Inasmuch as the engineman is frequently out of sight of critical yard operations in this case, it is important for him to know that he is in constant touch with the control point at the "hump" and that in event of equipment failure a positive indication will be given.

INTRA-TRAIN TELEPHONY — Radiotelephony is also expected to be of particular value in intra-train communications services such as cab-to-caboose signalling. The longest test of radio communication in point of mileage so far reported was made recently by the Santa Fe Railroad. A 70-car train traveled 2200 miles from California to Chicago, using radiotelephone communication between caboose and engine under all conditions of weather. After the trip, railroad officials forecast a rosy future for radiotelephone on rails. An ultra high-frequency amplitude modulation system, supplied by Bendix, was used. A telephone hand set, loudspeaker, low-powered transmitter, superheterodyne receiver, and power supply were installed at each end of the train. The only hitch in receiving signals on the trip came when various parts of the long train were in three tunnels simultaneously.

Several railroads are trying two-way communication for various purposes, using both audio and frequency modulation. Whatever is learned will be made available to the railroad industry To eliminate duplicate testing, other railroads are watching these experiments.

Induction radio systems operate at radio frequencies, but the signal energy travels primarily along wayside telegraph wires instead of through space No wire conductive connections are required to rail or wire circuits Privacy of communications, as compared with normal space radio systems, is maintained, and equipment may be operated without Federal licensing.

Since telephone, telegraph, or electric power lines follow closely most railroad trackage, the extensive wire network required for operation of induction radio systems on a comprehensive basis is already largely existent. In the limited number of instances where wires leave the vicinity of the railroad right-of-way for distances greater than several hundred feet, inexpensive installations of one or two wires across the gap will carry the carrier signals to the points where the normal wire circuits again are in proximity to the tracks. Signals impressed on wayside wires will follow the curvature of trackage in sections where space-radiated signals cannot readily be received without the aid of repeating equipment.

In rail carrier telephone systems, carrier signal energy is fed directly to the rails. Current flow is through the rails, with return through ground, and the concentrated induction field produced by the rail current is utilized in reception by means of pickup coils under the cars.

Rail carrier telephone communication systems are useful only within a short lateral distance of rail circuits. Since appreciable radiation of radio wave energy does not occur, such systems do not require Federal licensing or frequency allocation. As signals are confined substantially to railroad property, a degree of privacy exists which is not ordinarily obtainable with space radio systems. Rail carrier telephone systems offer means for effecting transmission of signals over comparatively long distances, sometimes in excess of 100 miles between wayside stations and trains and over distances of 10 miles or more between trains, with relative absence of "dead spots" at bridges, tunnels, and other obstructions to normal space radio propagation.

The system permits the crews of freight trains and block operators in wayside towers to talk to one another at any time for the transmission of orders, reports, and information on matters affecting train operation The conductor in the cabin car and the engineman in the locomotive cab may also communicate with one another and the crew of one train may talk with the crew of another train several miles distant

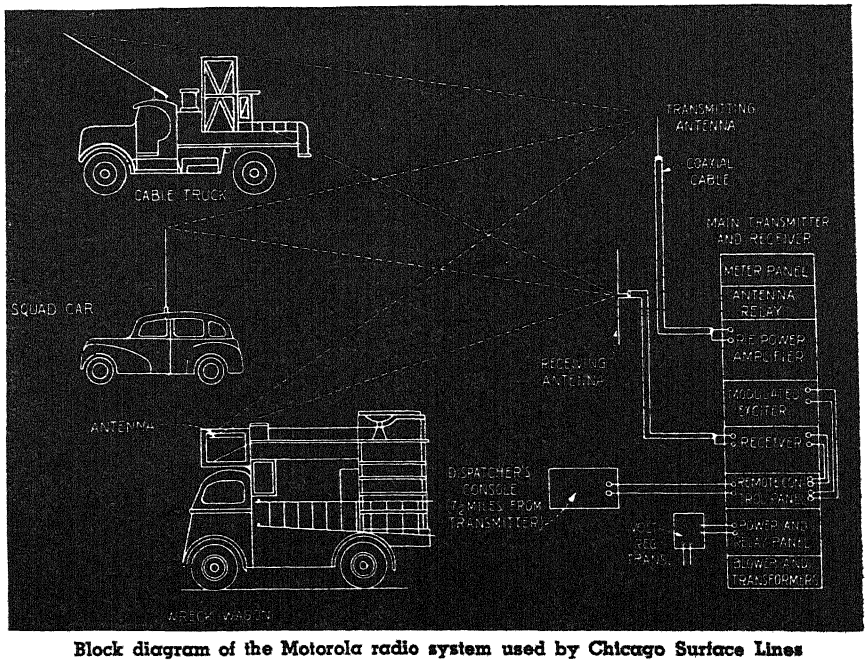
The elimination of stops at telephones alongside the tracks, to enable train crews to get in touch with block operators, has resulted in a considerable gain in operating efficiency, and no change in the operating rules governing the movement of trains has been found necessary. The same formulas are used

Manufacturing plants can also profitably use two-way radiotelephone equipment for speedy and efficient communication between executive positions and personnel walking or traveling continually around the plant on floor trucks. Here portable battery-operated walkie-talkies such as are now used by the armed forces will provide ample signal power for communication over the ranges existing within the average factory and grounds This type of equipment has also been used successfully by broadcast stations for remote program pickups from convention floors, golf courses, and similar locations where usual power facilities are not available

Another of the railroad communication systems, that involving carrier signals over wires, has been successfully used for keeping the operator of an overhead factory crane in continuous touch with men directing lifting operations from various points on the factory floor.

Just as hand-written telegrams are being transmitted by facsimile from unattended machines to Western Union central stations, so can facsimile radio transmitting and receiving equipment be utilized for getting blueprints and diagrams from one plant to another within a matter of minutes even though the plants are at opposite ends of the country. It is today technically possible also to install television equipment that will permit an executive to watch from his desk the manufacturing operations in any part of his plant merely by pushing buttons to switch-in appropriately positioned television pickup tubes throughout the plant.

EMERGENCY SERVICE—The form of frequency-modulated radio communication system which is being used by the Chicago Surface Lines to provide city-wide coverage for emergency operation now has a background of two years of successful operation. Forty-four mobile units with two-way radio equipment and seven supervisory cars with receivers keep streetcars and buses oper-



Block diagram of the Motorola radio system used by Chicago Surface Lines

Handie-talkies, of the type shown here in use to report a golf tournament, can be applied to a number of industrial communication purposes

ating smoothly under all emergencies, proving the effectiveness of low-power radio in covering 190 square miles of territory.

The system fulfills an important need when fires, floods, accidents, or other emergencies endanger life and property and normal communication is not readily available. It has even been called upon to obtain medical attention for streetcar passengers suddenly taken ill, and in at least one case a company car became an emergency maternity ward. Furthermore, by bringing company cars to accidents promptly, the system has materially aided in adjustment of claims and reduction of losses.

Fifteen wreck wagons equipped with two-way units are located throughout the city of Chicago in the company's garages, which are connected by telephone lines to a dispatcher's office. These wreck wagons serve to remove stalled vehicles from the right of way; clear collisions between vehicles when these occur at locations which would block the passing of the company's passenger-carrying units; guard fallen wires and feeder cables while awaiting arrival of regular repair crews; cooperate with the fire department at fires to maintain regular transportation and to safeguard life and property; and perform similar emergency functions.

Eleven two-way mobile units are located on trucks equipped to handle the installation and repairs of overhead contact wires and feeders. These trucks are also available for emergency service. The remaining installations are in cars that cruise along trolley lines throughout the day.

A plan proposed by Cab Research Bureau, Inc., representing the taxi industry, and the Electronic Department of General Electric Company, would make it possible to establish contact by radio with any cab at any place in Cleveland, reduce cruising mileage, and eliminate unattended call boxes connected to telephone lines. If approval can be obtained from the FCC, this would be the first two-way taxicab radio system in the country. The plan calls for one main transmitter for the downtown area and two others to cover the rest of the city. Each transmitter would have four channels, with 100 cabs assigned to each channel.

RADIO ON THE LAKES—The Great Lakes shippers are using radio and exploring radar as protection against the peculiar perils that beset their vessels. The radar system is expected to minimize the danger of collision in blinding fogs of early spring even as the radiotelephone has helped reduce the hazards of wind and current The ship-shore telephone system has been developed to the point where it keeps 580 vessels in constant touch with each other, home offices, Coast Guard stations—any point with a telephone.

More than 400 of these vessels are served by the Lorain County Radio Corporation One shore station at Lorain, Ohio, communicates with ships on all five of the Great Lakes. Another station at Duluth reaches ships and ports on Lake Superior. A third at Milwaukee serves Lake Michigan ships and ports

Because the sets are operated by navigation officers generally unskilled in radio, fully automatic equipment has been developed Lifting the handset turns on the transmitter. The channel appropriate to distance and conditions is selected by dialing two digits, and the land call is placed with the shore station operator. Call cost is 75 cents station-to-station, 90 cents person-to-person. Long distance toll charges on land are not included.

A six-frequency ship station costs about $2500 installed. Usually sources of interference on board must be eliminated. There is a flat monthly charge of $25 for maintenance It includes a monthly inspection, and dispatch of a serviceman upon the report of trouble

With the production tempo of military communications equipment due to ease shortly and with FCC and other governmental agencies now considering the problem of post-war frequency allocations to transportation radiotelephone services, this commercial application of electronics is already well started. The railroads have been able to obtain modern equipment in recent months for exhaustive tests preparatory to large-scale installations, and mass-produced commercial versions of military radio equipment may even be available before the end of the war as the WPB gradually lifts restrictions on non-military production.

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ELECTRONIC DRYER

Applied to Speed Production of Penicillin

PRODUCTION of penicillin has soared to a point where the output in March, 1944, was a hundred times that in the first five months of 1943. Civilians are promised supplies of the new drug sufficient to treat all urgent civilian cases in the relatively near future.

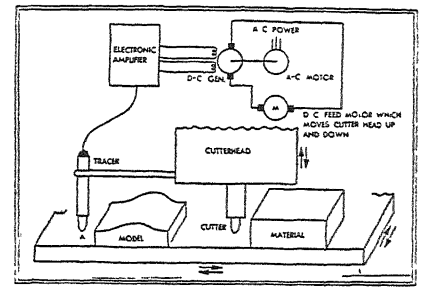
One reason for this increased production may be found in the recent use of an electronic dryer Formerly, the final bulk reduction of penicillin solutions required approximately twenty-four hours. Recent tests at the Squibb plant disclosed that it can now be accomplished within 30 minutes. The equipment was developed by Dr. George H Brown, RCA research engineer. High-frequency current boils the solution at 50 degrees, Fahrenheit, under moderate vacuum, resulting in evaporation at the rate of two liters an hour. In more conventional processing, solutions are dried—while frozen—under extremely high vacuum.

ELECTRONIC TRACER

Speeds Machining of Irregular Surfaces

A NEW electronic tracer mechanism has been successfully applied to several machining operations that involve irregular surfaces, such as propellers, dies, and cams.

The machine contains a probe which is used to follow the contour of an accurate model, either actual size or to scale. As the probe is moved across the model, an electronic amplifier feeds motors that move a cutting tool correspondingly with respect to the work.



Probe *A* follows the model's contour

With a well designed machine tool and an actual sized model, the contour of the model can be duplicated within two or three thousandths of an inch when a feed speed of twenty to thirty inches per minute is used.

SOUND ON FILM

Recorder Embosses Sound Track With Sapphire Needle

THE now famous broadcast by George Hicks, Blue Network correspondent, (an eyewitness account of a Nazi aerial attack on Allied ships in the first stages of the invasion) was made on a recorder using 35mm movie film.

The machine embosses a sound track on blank film and can record 120 lines across the width of the strip. This provides a 12,000-foot sound track on a 50-foot film—about five hours of steady recording. The embossing is made with a sapphire stylus mounted in a magnetic head that presses against the film when it is supported by a resilient pad. A second sapphire in a magnetic head is used for playback.

An important feature of the machine is that starting and stopping are controlled by either a manual switch or electrical impulses of voice or sound.

Chemical Guardians of Fabrics

Processes Have Been Developed Which Protect Various Textile Materials Against the Ravages of Fire, Water, Mildew, and Moths. Cotton has been Made Shrink-Set and Crease-Resistant. The Goal of the Industrial Textile Chemist is Now to Develop an All-in-One Treatment

By STEVEN M. SPENCER
E I du Pont de Nemours and Company

THE FABRICS of war have been equipped, through chemical research, with various kinds of invisible "armor" which have enabled them to resist fire and water, arctic cold and tropical humidity, mildew, moths, and soil bacteria, in a manner our grandfathers would have considered to be nothing short of miraculous.

Civilized man has for many centuries used the fleece of the sheep, the fiber of the cotton boll and flax stalk, the filament of the silkworm, to keep himself and his family decently and more or less attractively clad. With these natural fibers he accepted their natural limitations. He recognized that moths ate wool, that mildew attacked cotton and linen, that few fabrics shed water, that most of them shrank and wrinkled, and that all of them would burn. But he did little to alter the fibers themselves, aside from combing them out straight, spinning them into yarn, and dyeing them in more or less attractive colors.

It was not until the modern chemist came along, with his penchant for improving upon nature, that modifications were made which gave the natural fibers and some of the synthetic ones valuable added properties, but which did not change their feel or their appearance. The emphasis on high performance of military fabrics did much to speed up textile treatment and finishing developments during the past few years, and the experience gained during this time has without doubt prepared the way for a much more extensive application of these processes to civilian clothing and other textile articles after the war.

WRINKLE-PROOF CLOTH—The textile chemists are talking, for example, about suits and dresses that won't wrinkle in the rain, children's clothes that will stay clean longer, and stockings that will snag less easily. House furnishings will also be given the advantages of invisible guardians of the fibers.

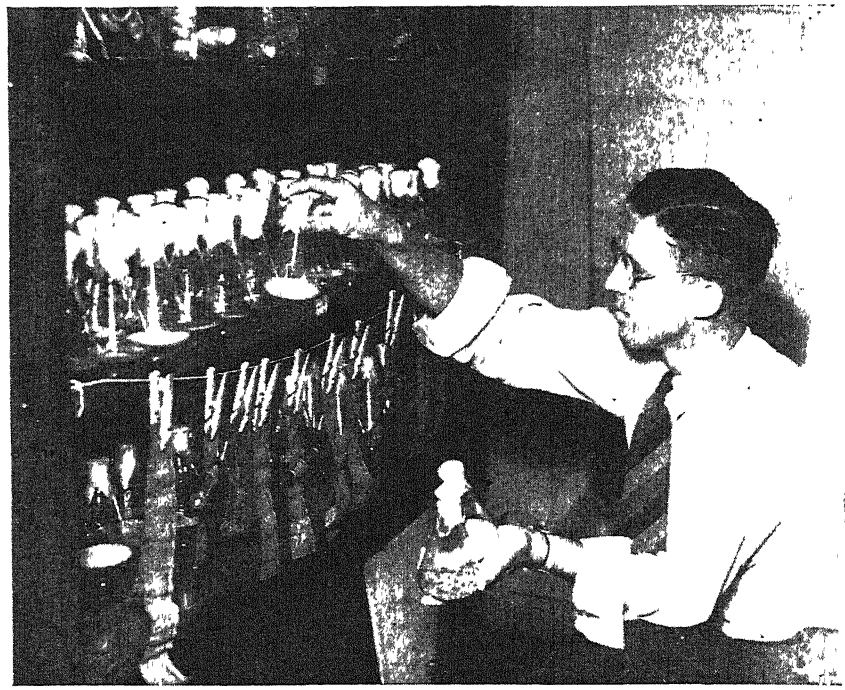
Among the most widely used fabric treatments are those which make garments water-repellent. This is distinguished from water-proofing processes, which render the fabric not only impervious to water but practically air-tight. The modern concept of rainwear is that the garment should keep the wearer dry without interfering with his natural cooling mechanism, the evaporation of perspiration. This objective has been achieved by water-repellent chemicals, which cause the fabric to shed water but which leave it porous so that it can "breathe."

There are also two broad divisions of water-repellent chemicals. One includes the wax-aluminum type of dispersion or emulsion, which forms a thin film on the fibers of the cloth and which comes off when the garment is laundered or dry-cleaned. It is possible to apply these treatments to the finished garment, renewing the treatment after each cleaning.

The second type is represented by "Zelan" durable water-repellent, which is a quarternary ammonium salt. This substance must be applied to the fabric before the garment is made. The process involves impregnating the fabric with the solution, passing it through a drying oven at a temperature of 350 degrees, Fahrenheit, and then washing it lightly.

The exact mechanism of the durable water repellent is not known, but one theory is that the chemical splits up during its application to the cloth and that the reaction products combine with the textile fibers to form a complex which repels water. It is interesting that in the treatment bath the ammonium salt is a wetting agent and penetrates easily into the fibers, but after the reaction has taken place it repels water and cannot be dissolved off by water or dry-cleaning solvents.

Every American soldier is familiar with water-repellent garments. One of the most popular items in his wardrobe is the field jacket, made of treated fabrics. Other military articles on



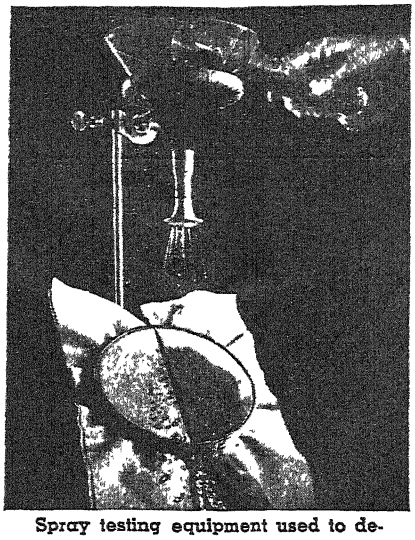
Fungi cultures, used to test the effectiveness of mildew-proofing chemicals, are examined in the Du Pont Pest Control Laboratory by Dr. Norman E. Borlaug. Strips of machine-gun belting, treated with water-repellant and mildew-protective chemicals, are hung in this special high-humidity room. Dummy shells are included to indicate any possible effect of the chemical agents on the metal

which durable water-repellents are used include combat jackets and trousers, ski suits, paratroopers' suits, officers' and nurses' trench coats with hoods, and mountain and arctic sleeping bags. Even machine-gun belting is treated to shed water.

In addition to keeping the wearer dry, the water-repellent fabrics have a weight advantage in wet weather, which is important to troops already heavily laden with equipment. If a soldier is wearing ordinary clothing it will soak up several pounds of rain during a march, which adds to his fatigue. Wading a stream will also pile pounds onto his burden. But water repellent garments absorb very little water and dry out quickly.

Through the use of various testing methods, in the development of which George A. Slowinske, of the Du Pont Company's Technical Laboratory, has been a leader, it has been found that the construction of the fabric and of the garment is of importance in the performance of water-repellent treatments The cloth should be of fairly close weave, such as a poplin, and if there is an under layer of flannel or other resilient material to act as a "shock-absorber" for the raindrops, they are less likely to drive through the fabric. In some cases both layers are treated.

SPOT RESISTANCE—The "molecular umbrellas" formed by the repellents not only shed water but make the garment spot-resistant. Non-fatty substances do not soil the treated garment as easily as they do non-treated fabrics, and when spots of these substances do get on they are easily sponged off with water. For these reasons the treatments are employed on children's play clothes,



Spray testing equipment used to determine the water-repellancy of a Zelan treated fabric (left) versus a sample of untreated fabric (right)

women's dresses, sports clothes for both men and women, and it is anticipated that they will be much more widely used after the war, not only on clothing but on upholstery fabrics.

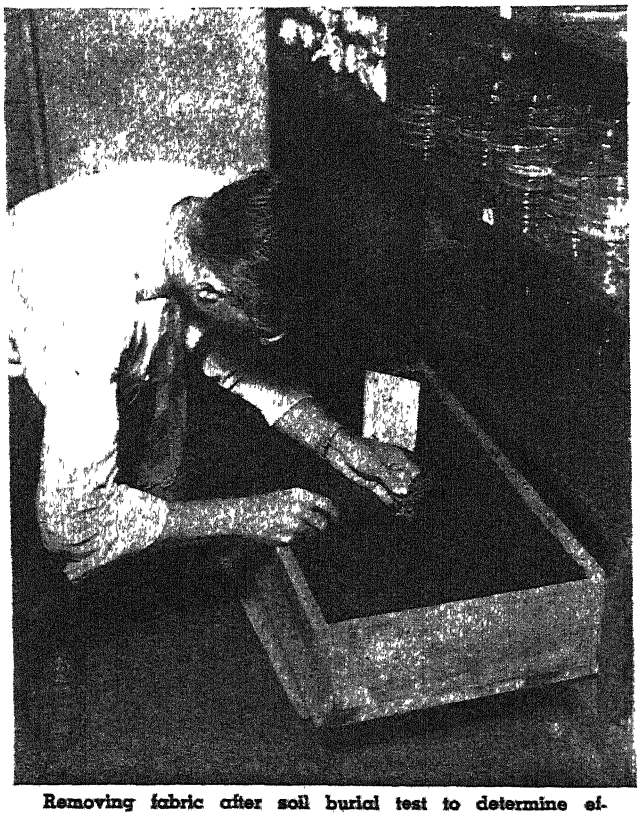
Water in a different form, that which we know as humidity, poses another problem for the textile chemists. Humidity promotes the growth of mildew, one of the most destructive enemies of cloth and of textile raw materials It is estimated that mildew damage to raw cotton alone averages from 25 to 27 million dollars in the United States each year. The fungus growths produce musty odors, stains, and weak spots in the fabrics. Those which cause decay of the fabric usually consume the cellulose as food, first secreting enzymes which help in the digestion.

The problem has been particularly acute during this war, much of which is being fought in tropical regions, where everything from shirts to shoes will mildew almost overnight. In the Pacific areas, canvas-topped jungle boots and ordinary shoe laces rotted away in a few weeks. The shoe lace difficulty was solved by making the laces of nylon, which resists fungus and bacteria attack. The same material is now being used for the uppers of the jungle shoes and for mosquito netting. But tents, hammocks, camouflage netting, and other cotton fabric articles had to be treated with mildew-proofing chemicals

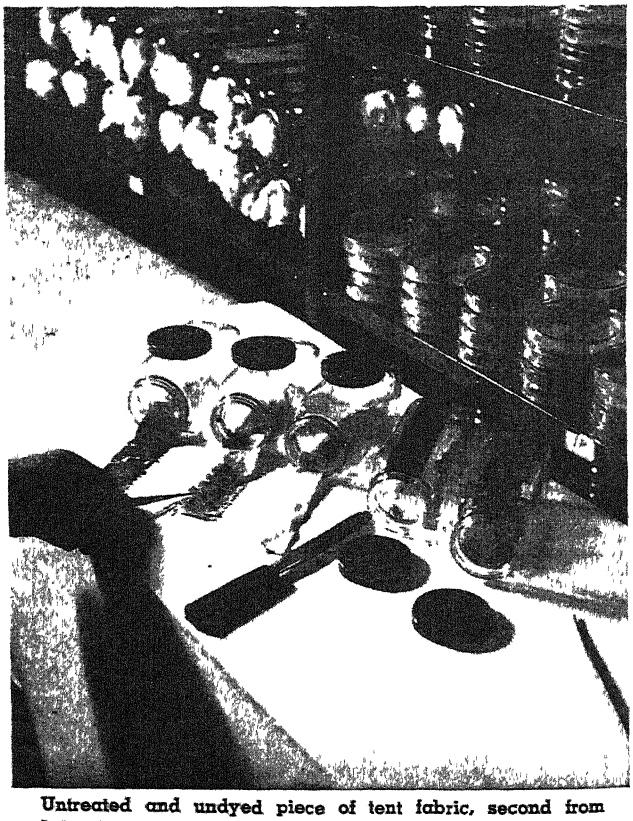
Where the fabric is exposed to soil bacteria, as in the case of cotton or jute sand bags for military revetments or for flood-control work, copper naphthenate has been extensively employed. Copper ammonium fluoride is another commonly used mildew-proofing agent

A newer development in the field of rot preventives for cotton fabrics is phenyl mercury oleate, which has the advantage over copper naphthenate for tentage that it is odorless and does not cause stiffening or tackiness of the fabric It is being tested on machine gun beltings, where its compatibility with water-repellent compounds is a point in its favor. Phenyl mercury oleate is non-volatile at temperatures up to 250 degrees, Fahrenheit, and is not leached out by water.

FIRE-RETARDING—Efforts to protect fabrics from damage by fire have been made periodically for the past three centuries, but it has only been within recent years that chemicals have been



Removing fabric after soil burial test to determine effect of chemical treatment in protecting against fungi and bacteria. Concentration of organisms accelerated tests



Untreated and undyed piece of tent fabric, second from left, shows rich growth of mold after 21 days contact with culture. Piece in center, treated, was protected

developed which are easy to apply and which do not affect the appearance and feel of the cloth. One of these is ammonium sulfamate, a salt of sulfamic acid. The acid itself had been known since 1876, but it did not become available in quantity until a few years ago, when an economical process was developed for manufacturing both the acid and the ammonium sulfamate on a large scale.

Fire retardants based on this salt have been employed for flame-proofing draperies and curtains in theaters and other public gathering places. During the war they have found important uses on certain confidential military items and in industries where workers are exposed to sparks or open flames. Garments and gloves, safety blankets (used to smother fires), welders' screens, and other types of fire screens are among the articles which have been treated

Cloth treated with ammonium sulfamate merely chars when held in a flame, but stops burning when the flame is removed. In other words, it will not support combustion—will not add fuel to the fire.

Another type of flame-proofing composition, a mixture of chlorinated paraffin with antimony oxide, has been used to flame-proof military tarpaulins and tents, applications for which ammonium sulfamate is not suitable because of its water solubility. Some of these treatments are also combined with mildew proofing.

MOTH WARFARE—The battle against moths is a never-ending one. It has been calculated that under favorable conditions—favorable to the moth, that is—the progeny of one female moth may in a year consume 92 pounds of wool fiber. And the damage to the wool, feathers, furs, and so on, in the raw and in manufactured articles, has been estimated at from 200 to 500 million dollars a year. The damage is much less if the wool is scrupulously clean, as every good housewife knows. And the moth-proofing of clothing, carpets, and upholstery is by now a fairly well established process, involving a dip or spray with one of a number of chemical compounds. Many of them contain fluorine.

An interesting new approach to the moth problem is that of Geiger, Kobayashi, and Harris, of the United States Bureau of Standards, who have conducted experiments in changing the structure of the wool itself to make it less edible to the moth larva. By chemical reactions they changed certain of the molecular linkages and reduced the content of cystine, an amino acid. The "built-in" moth-proofness is still in the experimental stage and is not being applied commercially.

Perhaps the commonest of all complaints against cloth articles is that they shrink or stretch when wet. Textile scientists call it "lack of dimensional stability" and they consider this their most serious problem. Shrinking is simply the result of the fibers' efforts to return to their original dimension after being stretched and held under tension during the weaving or knitting

Untreated cloth burns rapidly. Sample treated with ammonium sulfamate only chars, does not burst into flame

process. A single cotton fiber, picked from a boll in the field, won't shrink when washed. But when a number of them are twisted together and then drawn taut in a loop they are in an unusual position. While dry, and particularly if the fabric has been treated with a sizing preparation, the state of tension is retained. As soon as the fibers are wet they swell, become more plastic, and are released from tension. They then seek to return to their original dimensions, and the result is shrinking.

Methods of pre-shrinking, such as the Sanforizing process, have brought about a great improvement in cotton fabrics, but they cannot be applied to woolens and rayons. Impregnation of the fabric with formaldehyde or urea-formaldehyde resins has been employed on cottons and rayons, and melamine resins have also been used. These treatments are designed not only to shrink-set the cloth but to make it crease-resistant. There are complicating factors in the picture, and much work remains to be done on both rayon and wool, but there is every expectation that the problem will be solved.

Other resins and chemicals are being made ready to do additional textile jobs. A urea-sulfuric acid treatment can be used to make organdy fabrics soft or crisp, transparent or non-transparent. Lucite methyl methacrylate resin, the transparent plastic which today makes bomber noses and which in pre-war days made many useful as well as attractive articles, will perform a new kind of practical and decorative function in providing a snag-resistant finish for women's stockings.

Processes have been developed for simultaneously making a fabric crease-proof and water-repellent, and the textile chemists' goal is an all-in-one treatment which will apply all the varieties of invisible protective "armor" at the same time.

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FLOOR CLEANER

Paves the Way

For Better Waxing

FOR LABOR-SAVING maintenance of floors, the Finishes Division of the Du Pont company announces the development of Pre-Wax Floor Cleaner as a companion to Du Pont Self-Polishing Wax.

The new dirt-chaser is a concentrated, heavy-bodied product of about the consistency of heavy cream, which is reduced with water for use on all types of floors before waxing or re-waxing. It is said to provide a good base for subsequent waxing, setting up a "bite" on the surface to give the wax better adhesion. Only worn areas will need re-waxing after use of the cleaner, as it rejuvenates the wax finish.

Directions for routine cleaning of waxed and finished floors call for one quarter cup of the cleaner to two gallons of water. The solution is applied with a saturated mop or cloth and allowed to dry before waxing.

For extremely dirty floors, one cup of cleaner should be used in one quart of water. This is applied liberally and allowed to remain on the surface for two or three minutes. On the extremely dirty areas it may be necessary to scrub with a stiff brush, steel wool, or scrubbing machine while the solution is still wet. After removal of the cleaner with a mop, squeegee, or cloth, the floor is rinsed with clear water to which a small quantity of the cleaner has been added. When dry, the floor is ready to be waxed.

ADHESIVES

Perfected from

Synthetic Rubber

DEVELOPMENT of a new line of synthetic rubber adhesives is announced by The B. F. Goodrich Company. One is for general "utility" use and is a type of adhesive which will adhere to almost any clean surface. It serves these purposes as well as natural rubber cements in the same field, the company says.

Synthetic cements are available for heat vulcanization, air curing, or cold adhesions. The compounded synthetic cements are suitable for fabric, leather, and synthetic adhesions, to themselves or to each other. These adhesives have a non-toxic solvent, and will give an excellent bond with a large variety of materials. They give the same bond, when used with cured or uncured Neoprene, that rubber cements give with natural rubber.

For metal adhesion, two special cements in what is known as the Plastilock 300 series, have been developed. The first is used with vulcanized Neoprene when it is bonded to porcelain, metal, and so on, while the second is used with uncured Neoprene.

Progress in Instrumentation

The Wartime Impetus to the Aviation Industry will Be Reflected in Many Ways Post-War, to the Benefit of American Aviation and of Other Peace-Time Industries as Well. The Philosophy of Instrument Research. Should Research be Kept Separate from Production? If Not, Where Should the Emphasis Fall?

No WAR can ever benefit a country in modern times, but war does provide impetus to certain types of instruments and appliances, to methods of development, and to production In these connections a recent visit to the Eclipse-Pioneer Division of Bendix Aviation Corporation proved of tremendous interest.

During this war Eclipse-Pioneer has developed, under the stringent demands of military and naval aviation, the most advanced instrumentation for the control and navigation of aircraft, and at the same time has immensely advanced the speed and accuracy of production methods. The improved instrumentation will benefit post-war commercial aviation, the better production methods will have an influence on American industry as a whole, and the methods of automatic control which have been fostered by flying will be adopted in modified form for a great many industrial purposes.

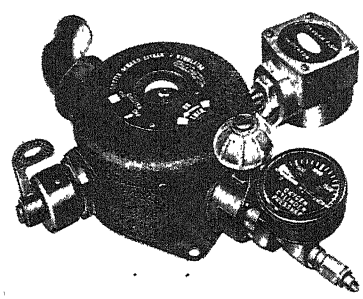
RUSSIAN ENGINEERS—In no direction was the *Herrenvolk* so mistaken as in its contempt for the Russians, for their ability in engineering and manufacture, and hence for their ability to wage modern war. We have proofs of their complete misjudgment in the great names of men of Russian origin who have contributed mightily to American science and industry: Sikorsky, the inventor of the helicopter; Zworykin, the originator of the electron microscope; Karapetoff, a leader in engineering experimentation and teaching—to mention but a few.

To these contributors to American life we can add W. A. Reichel, the Director of Engineering of Eclipse-Pioneer. A graduate of the Petrograd Polytechnical Institute in electro-mechanical engineering, son of a father who himself led in Russian instrumentation, Mr. Reichel has for 20 years (after initial experiences on our shores which involved hardships and taking any job he could get) pioneered in developing one aircraft instrument after another, beginning with an automatic steering device for aircraft and ending with the numerous advanced aviation instruments and controls now being built under his leadership.

The word research, Mr. Reichel urges, is greatly abused. Used alone, it should be reserved for the achievements of an Einstein or a Langmuir in the fundamentals of science and not allotted so freely to industrial experimentation —though this is thoroughly deserving of respect. In industry experimentation should be well and carefully guided Ingenious ideas are plentiful. The skill of our directors of research and engineering lies in guiding activity to useful and concrete ends, also in rejecting the majority of the ideas submitted, no matter how clever, if they appear to lead to no useful goal or salable product. On the other hand, if our industrial research is to be practical, it should make every effort to keep abreast of optics, heat, electricity, magnetism, chemistry. The experimental staff should include physicists as well as engineers, mathematicians as well as practical shop men.

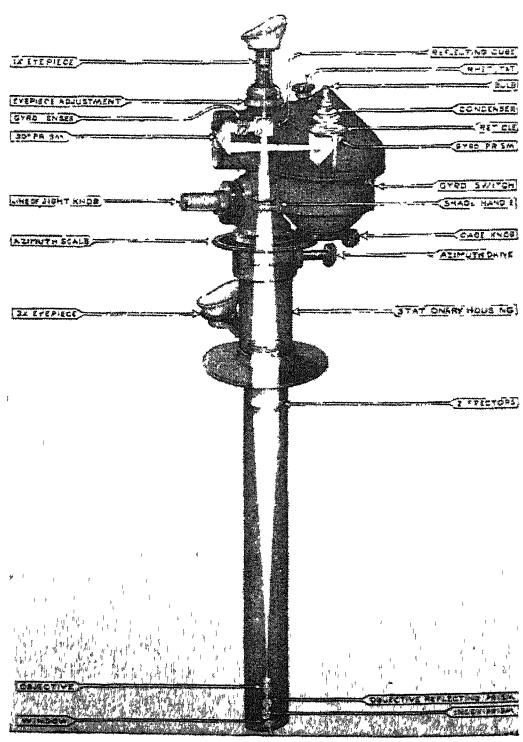
To this universality of talent there should be added, Mr. Reichel insists, an eye to production methods from the earliest inception of the design. In many centers of development in industry the experimental development is divorced from the manufacturing side. As a result, instruments and machines are first built in an experimental manner, with attention concentrated solely on function. Afterward the actual production mdel is undertaken Mr. Reichel is of the strong opinion that therein lies an indefensible waste of effort—that such procedure amounts to developing two machines or instruments instead of one, and that it is impractical and unwise to separate engineering from manufacture.

Eclipse-Pioneer experience has indicated that it is perfectly possible to train both engineers and draftsmen to keep in view the dual ends of function and manufacture, that such training can be rapid; and that once a man has assumed the appropriate attitude, he can design experimental devices with production kept in mind, just as rapidly as if he had adopted the "prima donna"



The Diluter Demand Oxygen Regulator, showing oxygen pressure gage and, at the upper right, the flow indicator

Right: Phantom diagram of the Eclipse - Pioneer Driftmeter, showing the light path



outlook on life and made "research design" his sole objective.

With this philosophy permeating the engineering department, it is not surprising to learn that the skilled experimental designers have also found means of simplifying and cheapening production methods.

Another important lesson in the conduct of research for industry has to do with invention and development. The old conception was that of an inventor starving in a garret, finally to succeed by the strength of his own genius, and with limited, improvised tools and instruments With the complexity of modern technology, one man's work and limited scientific resources can no longer achieve all that we need. The lone inventor, however, had great advantages: individual initiative and enthusiasm, freedom from too much direction and from too many committees and conferences. The question is. How can the individuality and enthusiasm of the lone worker be combined with the resources of a modern industrial plant where many men in different lines of science are backed up by fine and specialized laboratories?

HERE IS THE SOLUTION—Everyone should co-operate, but for each new development a project engineer should be appointed whose business it is to see the whole thing through—from the very inception, through the construction of the first experimental device, to its testing in the laboratories and, finally, in the case of aviation, through actual flight tests at Army or Navy fields, and sometimes even to inspection in combat areas.

But, while Eclipse-Pioneer thoroughly believes in production coupled with engineering, not too many models of a given device are built at first. Ten or perhaps twenty new instruments will be constructed, to give a sufficient number for testing and for discovering bugs, but not enough to cause delay and financial loss in scrapping larger numbers should tests reveal serious errors. No amount of work in drafting or laboratory can reveal all the imperfections that can creep into a new design.

Director of Engineering Reichel brought up another marked advance in production processes. In making small and accurate parts, the objective is to fabricate in such a way as to remove the least possible amount of metal. Under stress of war needs, a process termed "coining" has come to the fore. In coining, an enormous pressure is exerted on a piece of metal—200 tons on a metal piece not more than two inches in diameter, for example. Under such a large local effect the metal flows like water. A single blow or percussion of an electrically operated toggle transforms the raw piece of metal into almost any complicated shape desired Next to no metal is removed, labor is reduced to the minimum and, above all, inspection is no longer needed.

Here are some of the guiding principles of the philosophy of instrument research, according to Mr. Reichel and his associates, Messrs. Moran, Noxon, and Baring-Gould. When an attack is made on a new idea, there should be no undue loss of time in its experimental construction. Cogitation and mathematical analysis are big helps, but it is impossible to foresee every point in the behavior of an instrument The gadget must be built and tried out. At first it looks splendid, and early experience is satisfying. Then troubles develop, enthusiasm cools off, matters look so bad that despair replaces elation. Tenacity and persistence are needed just as much as ingenuity—and courage above all.

Where difficulties are really serious, workers should not be afraid of fundamental and original thinking—of turning to the physicist capable of leaving the beaten track and of reaching the very ends of science.

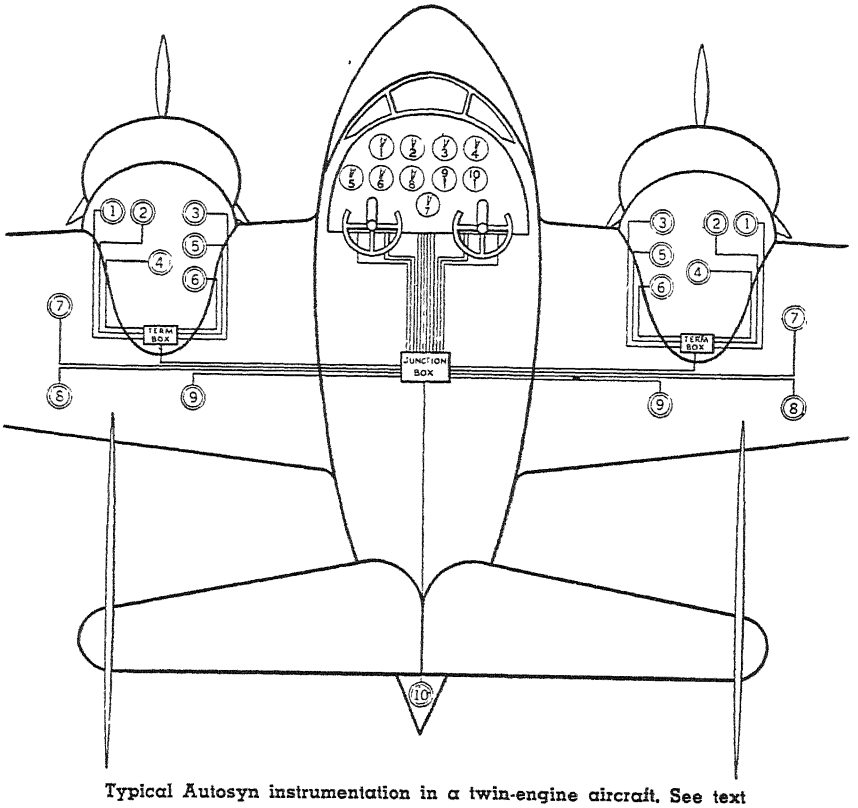
As has been stated, the war has hastened development. There has been rapid improvement in three types of instruments: navigational aids, controls for flight and engine, and in what might be called the standard navigational instruments For example, consider the "Diluter Demand Oxygen Regulator." Lack of oxygen plays strange tricks on the flyer, giving him a species of jag and rendering his judgment very poor The regulator takes in oxygen from "bottles" at 2000 pounds per square inch pressure, and delivers it to the pilot in just the right amount and just at the right pressure, with pressures and flows clearly indicated, and with the lungs and breathing needs of the pilot as the unconscious and completely satisfactory guide.

The engineer should not be satisfied with only a single application of the instruments on which he is working. He should seek many applications, and learn association of ideas and purposes. For example, aviation demanded a system of remote indication, needed in placing the magnetic compass where it is not affected, or not much affected, by the presence of steel in the airframe. Once remote indication was achieved, was it not logical to proceed to remote control? So remote control grew from remote indication. Next, effective remote indication and remote control led to the development of an electric motor of very low inertia which will swing lightly and instantaneously from one side to the other as the exigencies of the situation demand.

The needs of remote indication led to the "Autosyn" Then, to furnish remote control as well as remote indication, "Autosyn" developed into "Magnesyn." The special needs of aircraft instrumentation led, in turn, to changes in the design of electronic tubes; to the development of tubes giving a logarithmic indication instead of the linear indication or amplification which satisfies radio; to a species of electronics more precise and accurate than anything required in voice transmission or even television: to electronic tubes with better shaped electrodes and other improvements.

In principle the Autosyn system represents an adaptation of the self-synchronous motor principle, wherein two widely separated units operate in exact synchronism—the rotor of one moving at the same speed as the rotor of the other.

In the Autosyn, the rotors neither spin nor produce power Instead, the rotors of two connected Autosyns come into coincidence when energized. Thereafter the rotor of one Autosyn moves only the short distance necessary to match any movement, no matter how slight, of the rotor of a second Autosyn. Transmitter and indicator Autosyns are essentially alike. Each has a



Typical Autosyn instrumentation in a twin-engine aircraft. See text

rotor and a stator. When alternating current is applied and a rotor is energized, transformer action causes three distinct voltages to be induced in the secondary stator windings. The voltage values vary with the position of the rotor relative to the stator. For each minute change in the position of the rotor, a new and completely different combination of three voltages is induced. When the two Autosyns are connected and their rotors occupy the same position relative to the stators, no current flows in the interconnected stator leads. Consequently both rotors remain motionless However, when the two rotors do not coincide in position, the combination of voltages in the two stators are dissimilar and rotation occurs, continuing until both rotors are identically positioned.

The transmitting or measuring part of the system is connected to a pressure gage, a float arm, or any other source of power or indication. The indicating Autosyn moves the pointer on the instrument panel. The Autosyn system has been applied to flowmeters, pressure gages, oil gages, and so on.

For overseas navigation our boys have some wonderful instruments to help them. The Driftmeter, an adaptation of the telescope, will show them drift to one side of the course, and tell them their ground speed instead of air speed. The war has brought to perfection many devices to help navigators on long range flights. Because of their confidential nature they cannot be disclosed at this time.

Eclipse-Pioneer has developed a very quick response automatic control, using a rate signal, superimposed on a departure signal. This automatic control is very fast and employs the latest developments in electronics and electronic servos. It can be used post-war for industrial controls or automatic pilots.

Of course such efforts as those of Eclipse-Pioneer, only briefly described here, will redound to the benefit of American aviation post-war. Planes, not only military and naval, but commercial and those intended for private flying, will benefit by new and accurate instruments for navigation and control. But it is also probable that these refinements in the instrument art will have a profound influence on many other American industries Additional knowledge will have been obtained in mechanical, electrical, hydraulic, magnetic, electro-magnetic, pneumatic, and electronic devices and controls. The almost miraculous accuracy, rapidity, and "dead-beatness" of a device such as the automatic control will give to industry methods of automatic control of the most varied character in metallurgical processes, in the manufacture of synthetic rubber, in fuel and oil refineries, in the chemical industries, in steel manufacture. The watchfulness and skill of human operators will yield to the far greater alertness and accuracy of the robot.

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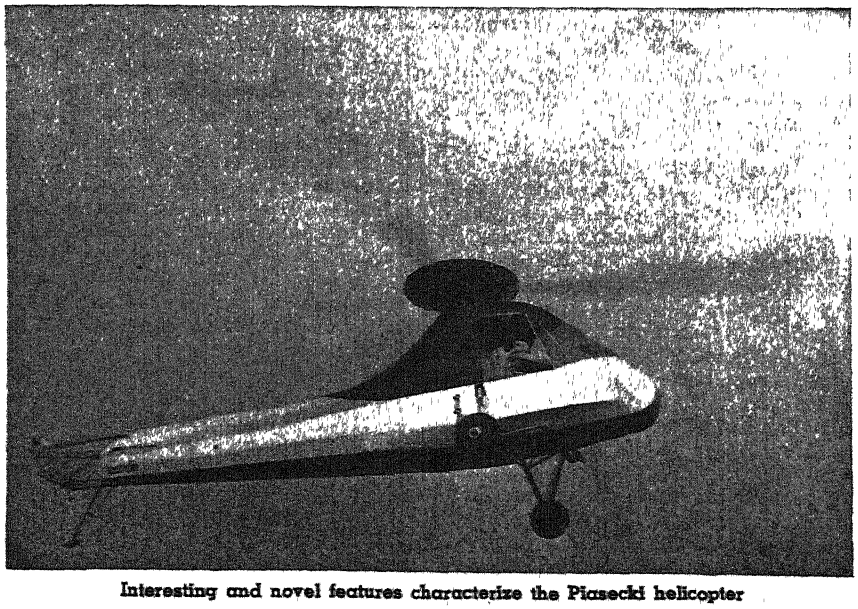
THE PIASECKI HELICOPTER

Features Ease of Control and Reduced Vibration

WHILE it has semi-conventional lines and a tail rotor, the helicopter designed by Frank N. Piasecki has some interesting and novel features. For example, the center of the rotor is completely enclosed in a three-foot discus, so there is no drag-producing void at the roots of the blades. Excellency of control and reduction of vibration are other features of the design; the well streamlined form and the neat way in which the tail rotor is supported on the extension of the nacelle are others.

The helicopter is equipped with a four-cylinder, 90 horsepower, air-cooled Franklin engine and has a high speed of between 90 and 100 miles per hour. The gross weight is only 1000 pounds. The rotor blade diameter is 25 feet, it turns at a speed of 350 revolutions per minute, and the chord of the blade is constant at 9½ inches. The anti-torque propeller at the rear has a diameter of five feet and rotates at about 1600 revolutions per minute while the ship is cruising. The control stick is suspended from the roof of the cabin, with conventional rudder pedals acting on the pitch of the anti-torque propeller It is interesting to learn that the pitch control can be set and the craft flown with the throttle alone For take off, the pitch control is set in the forward position and the throtttle opened until the craft ascends vertically The stick is then pushed forward for forward motion, and subsequently the throttle can be eased back to maintain cruising speed



Interesting and novel features characterize the Piasecki helicopter

AIR TRAMPS

May Find a Place in the Air Transportation Picture

WHEN OUR war pilots come back and turn, perhaps reluctantly, to prosaic peace-time pursuits, some of them will perhaps find in the "air tramp" an adventurous, satisfying, and lucrative activity. At least that is the opinion of Mr. Thomas Olsen, partner in a Norwegian shipping company, one of the directors of the Norwegian Air Line, and fully qualified to discuss the air tramp on the score of this dual activity.

Surface liner shipping has not superseded the tramp steamer. Why should scheduled airlines preclude the coming of the air tramp? Certainly in these days of mass organization, of governmental regulation and indirect subsidy, the bulk of the world's air traffic will be in the hands of the regular air lines. Yet there will still be a place for the air tramp.

Aviation's chief contribution to international transport is speed, but there are other advantages such as the availability of smaller units, flexibility in arranging new routes, the short time in which a plane can be refitted to the needs of particular cargo. In the post-war period many strange tasks will be placed before the transportation man, involving the use of delicate machinery and the carriage of costly raw materials, and calling for great speed. Perhaps the air tramp will be very useful indeed. In the old days the captain of the tramp steamer roamed the four corners of the earth, picked up cargo wherever he could, and even advised merchants as to commercial possibilities. Why should not the captain of the air tramp engage in similar exploits?

AIR SAFETY

A Number of Organizations Co-operate Fully

IN THE article "Safety In The Air," published in our August issue, mention was made of the work of the Cornell University Medical College. To this should be added the fact that credit is also due for work on crash injury research to the National Research Council Committee on Aviation Medicine working with the Committee on Medical Research of the Office of Scientific Research and Development. Also that the photographs used in the article were used by courtesy of *Aero Digest.*

Continuous Hardening

High-Frequency Process is Being Commercially Applied to Treatment of Steel Bars of Various Diameters, Shapes, and Lengths. Results Thus Far Show Appreciable Savings in Costs, Plus Increased Machinability. Equipment is Virtually Automatic and Requires a Minimum of Man-Power

PROBABLY destined to have far-reaching effects in the field of steel treatment is the successful application of high-frequency induction to the continuous heat treatment of steel bars.

Already on a commercial basis, this first bar application may prove to be one of the major contributions made by induction heating to industrial operations. Inductively hardened bars reveal improved machinability while heat-treatment costs are, in most cases, lower by 50 percent than those for conventional methods long considered standard. An actual saving of $15 per ton is possible.

Success of this development is reported to be due to The Ohio Crankshaft Company, designers and manufacturers of Tocco equipment that is now being used by The Caterpillar Tractor Company.

Says President Wm. C. Dunn of the Tocco manufacturers: "The development of this new method of heat-treatment of steel bars provides an easy means for treating small lots as well as large quantities. One has only to push a button to accomplish the hardening. Now for the first time complete uniformity of hardness has been accomplished so that bars inductively treated by this process have greater machinability because of the elimination of hard spots. In every way, quality of stock and the end result is improved."

The Caterpillar Company is treating bars from ½ to 1¼-inch outside-diameter, hardened through their entire diameter and free of scale and decarburization. Growth is negligible and the heat-treating cost per lineal foot is the same for one bar as for a thousand bars. Therein lies one of the most interesting aspects of this application, which has proved itself to the point where it is now no longer in the experimental stage.

In the perfection of this application there was close co-operation between Tocco engineers and the top metallurgists of Caterpillar. The bar unit is an adaptation of the method for continuously hardening track pins which was introduced some time ago.

The equipment comprising this initial bar-hardening installation consists of four identical hardening units and two standard power units. The hardening units, built on rigid cast bases, are 11¼ feet long by 37 inches wide by 38 inches high. Three roller housings rise above this heavy base to a height of 16 inches. These housings are 16 inches square and contain the roller mechanism for passing the bars into and through the inductor coils.

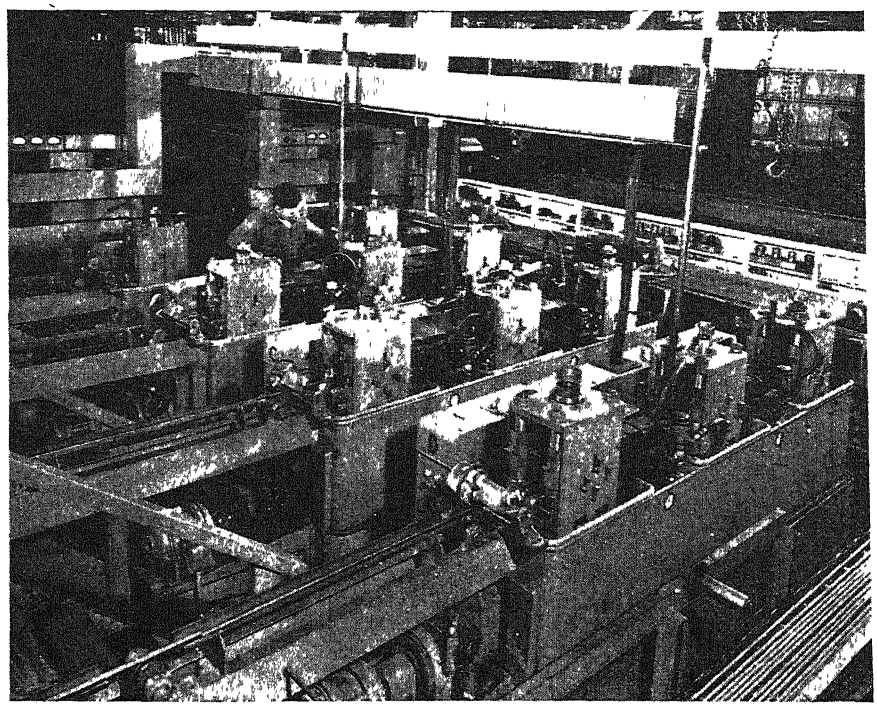
The four hardening units, which are set parallel, each carry two water-cooled copper inductor coils, one for hardening and the other for drawing. Spaced between the roller housings, the coils are 17 inches in length and have a diameter sufficient to treat 1¼-inch steel bars. A quartz tube liner protects the inductor.

Bars are passed into and through the heating coils at controlled speed by means of three sets of special feed rollers located in the aforementioned housings. The rolls are adjustable, allowing for a variation in bar diameters, are driven by the same motor, and are governed by the same variable speed control unit, thus insuring uniformity.

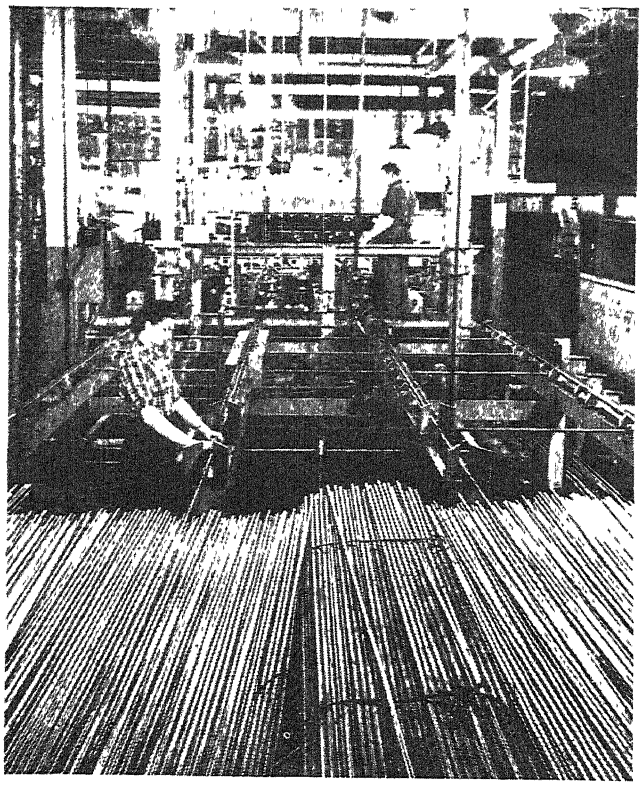
Power is developed by two standard 9600 cycle, 440 volt motor-generator sets; one, of 125 kilowatt output capacity, operates the four hardening coils which are in parallel and the other, of 75 kilowatt capacity, is for the draw coils and is also in parallel. Voltage on each group of coils is held constant by an amplidyne voltage regulator.

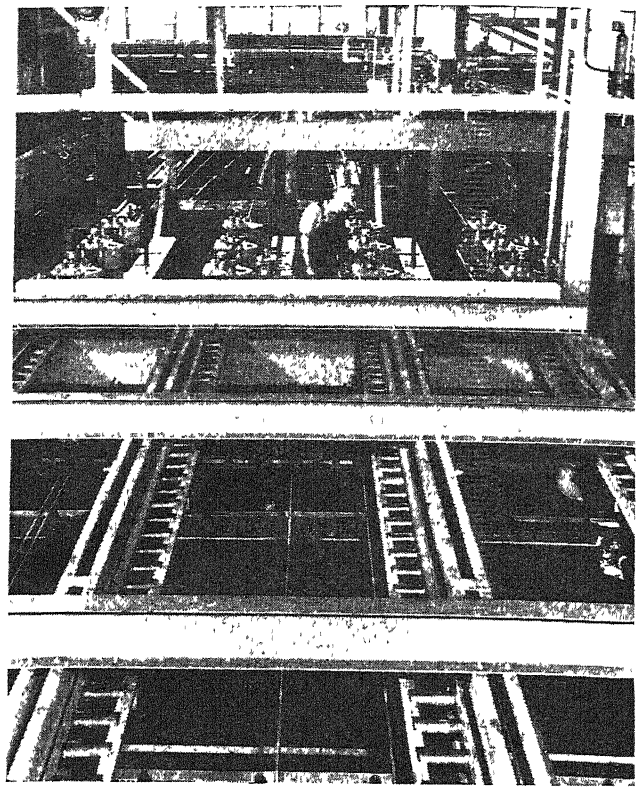
Success of this continuous operation is closely related to the positive drive that governs the rolls. Because of this device, uniformity of hardness is duplicated in all bars and along every inch so that there is complete freedom from hard spots. In a 20-foot bar hardness is held to within two points on the Rockwell C scale for the full length of the piece.

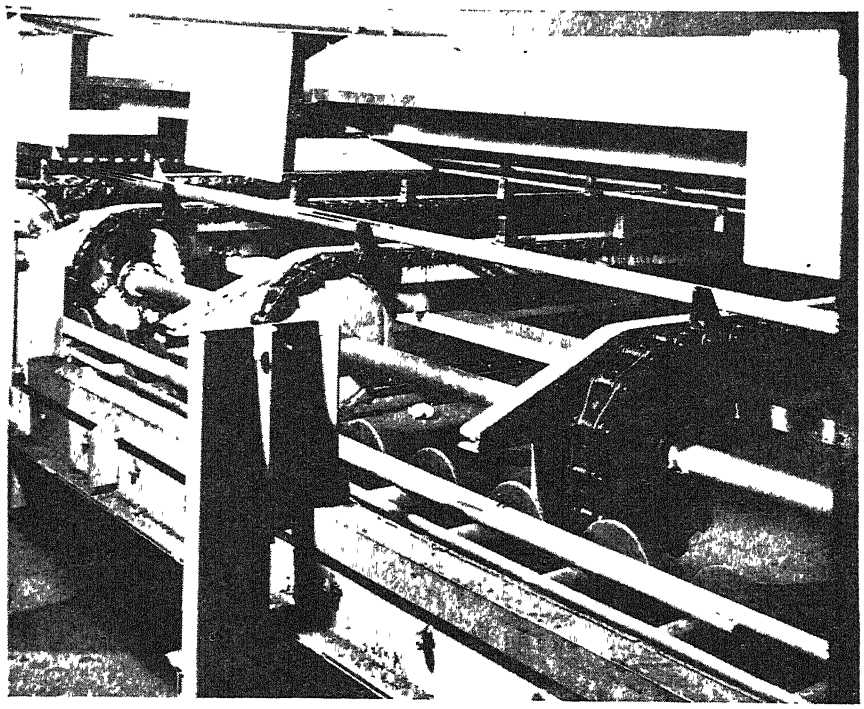
At Caterpillar it is reported that S.A.E. 1035 rounds currently comprise the majority of bars being treated. The resultant hardness averages 28 Rc. Yield strength runs about 112,000 pounds and tensile strength 129,000 pounds. Elonga-



Overall view of continuous hardening units. Speed control rollers are in the three housings on the base, with induction heating coils located between them







Upper left: Bars to be heat-treated are fed end-to-end from a stock pile into a motorized conveyor that carries pieces directly to the inductor coils. Only two operators are required to handle the four units

Above: Following hardening and drawing, the bars emerge onto the narrow roller conveyor in foreground

Left: From the roller conveyor the bars are dropped to this chain type conveyor which, in turn, drops them to another roller conveyor that carries the bars to the storage area

Below: Every fifth heat-treated bar is checked for Rockwell hardness

tion averages 23 percent, reduction of area 62 percent, and Izod impact strength 80 to 100 foot pounds

Bar hardening is applicable to all hardenable alloys as well as simple carbon steels. Further, hardening is not limited to rounds; hexagon and other shapes can be treated with but a minimum of effort required to change inductors and rate of feed for the new bar.

The bars are fed into the treating units over a motorized conveyor which passes them through a sodium phosphate wash before engaging the first rollers prior to entry into the hardening coil. The cleansing spray is heated to 190 degrees, Fahrenheit, and removes any foreign matter that might otherwise fall off in the induction heater.

Typical of the functioning of this installation is the hardening of 7/8-inch bars. Four bars are fed through the four hardening units, each bar being heated throughout its cross-section to 1600 degrees, Fahrenheit, while traversing the hardening coil. As the piece leaves the first inductor it is quenched in a solid cone of water that surrounds the bar. The water, held to 80 to 90 degrees, Fahrenheit, is under 60 pounds pressure. The bar then passes into and through a reheating coil where it is drawn at a temperature of 1125 degrees, Fahrenheit, after which it is usually passed through a cooling quench to facilitate handling. Natural gas is intro-

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duced into the coils to provide an inert atmosphere for the prevention of scale

Speed of the 7/8-inch bars through each of the units is at the rate of 22.8 inches per minute Other sized bars travel at a different rate of speed so that the ultimate production of this particular installation is approximately one ton every 120 minutes.

The bars pass through the final set of rollers and out onto a narrow conveyor moving forward until a limit switch is tripped. This rolls them onto a chain drive conveyor which carries the pieces to a third conveyor running parallel to the entire assembly back towards storage.

Close check of treated stock is maintained. Every fifth bar is tested for hardness and end samples are frequently cut for laboratory inspection.

Significant to other industries is the fact that, by actual check, 90 percent of steel bars 7/8 inch and over come from the inductors without the need for any subsequent straightening while 85 percent of sizes under 7/8 inch are ready immediately for machining.

Bars treated in this continuous process are not limited in length. Caterpillar is treating pieces ranging from 18 to 24 feet. Material may be either cold finished or hot rolled if straight. The diameter of the steel bar determines the diameter of the heating inductor and the closer an inductor is to the outside diameter of the bar, the greater is the heating efficiency.

It is estimated that one man can operate four of these units with ease. At Caterpillar a man and a woman handle the entire installation including checking of hardness.

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HYDRAULIC BARKER

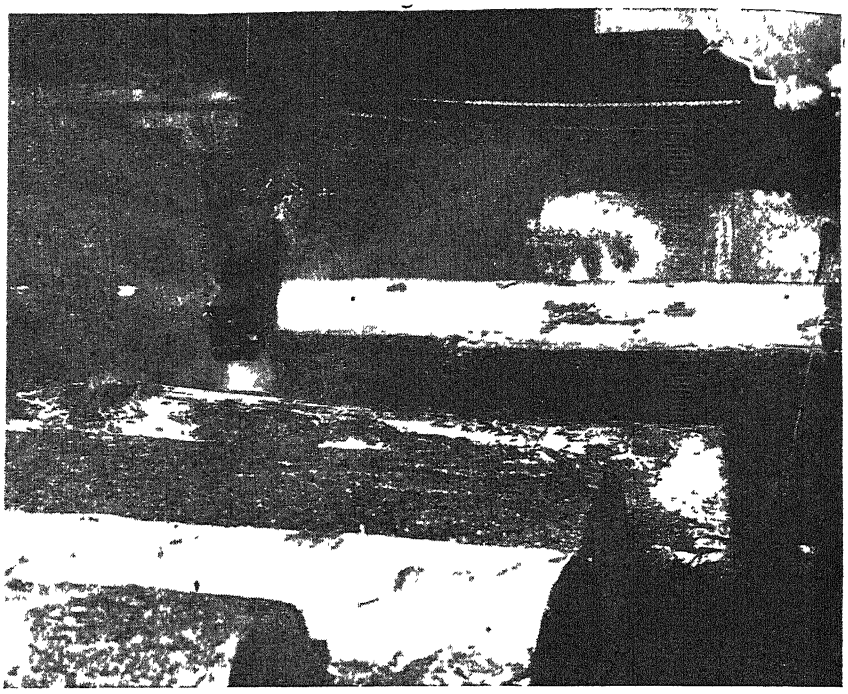
Debarks Pulpwood

Logs Without Waste

INGENIOUS mechanics in the far northwest corner of the United States have designed a machine to take the bark off pulpwood logs without taking useful wood with it. This accomplishment of Harry Bukowsky, Plant Engineer, and E. W. Erickson, Resident Manager of Crown Zellerbach Corporation, has far-reaching implications. It means, for example, that anywhere from 6 to 20 percent less wood need be brought from the woods to a mill to produce a given pulp tonnage. This is equivalent to boosting forest growth by a similar proportion or to the addition of new reserves in the woods.

The tiniest piece of bark will ruin paper pulp, and the old-fashioned debarking methods, in order to remove all the bark, also removed part of the valuable wood. The new barker permits no such waste since it removes only the bark from a log.

Working on the lathe principle, the new hydraulic barker is simple in design and operation. Instead of a cutting edge of steel, a cutting "knife" of water, under high pressure, played on the rotating log, removes all bark and will clean nearly 100 logs an hour. It will handle western hemlocks as big as 54 inches in diameter and as long as 22 feet.



To the logging and pulp industries the hydraulic barker means more pulp tonnage for a given number of trees cut. Debarking waste is virtually eliminated

Logs are brought to the barker on a chain transfer. Powerful steel loading arms lift them off the chain. A nozzle with a four-inch pipe, suspended from a carriage which travels on a trolley above the log, is lowered into position for the barking operation. The log is rotated and the nozzle, controlled by an air cylinder, travels lengthwise alongside it. A jet of water strips the log of its bark by hitting it at an angle with a pressure of 650 pounds per square inch. The nozzle advances its own width for each revolution of the log. Thus it will cut off a seven-inch swath of bark with each revolution. The nozzle carriage is fitted with swing joints to permit a 24-foot travel.

Refuse from the barker is carried away by a conveyor. Examination of this refuse confirms the efficiency of the barker because it rarely contains even a sliver of wood. The bark peeled from the logs is put to good purpose—going into the furnaces of the paper mill boiler room to be transformed into power.

DRIED, CANNED

Foods Show Best

Keeping Qualities

DEHYDRATED vegetables and fruits retain their original flavor, vitamin content, and form best when packed in metal containers and hermetically sealed in nitrogen or carbon dioxide, experiments conducted by the Chicago research department of Continental Can Company reveal.

Undertaken in co-operation with the Subsistance Research Laboratory of the Chicago Quartermaster Depot of the United States Army and with the help of many food processors, these experiments represent the first comprehensive attempt ever made to determine the effect of packaging, storage time, storage temperature, and moisture absorption on the quality and vitamin content of packaged dehydrated fruits and vegetables. Heretofore, very little has been known on this subject, despite the rapid war-time growth of this relatively new food processing industry.

Eleven representative dehydrated fruits and vegetables were submitted to four experimental packings. In three cases, samples packed in No. 1 tin plate cans were sealed in nitrogen, carbon dioxide, or air; in the fourth, each food was packaged in three-ply paper bags. Samples of each packaging method were stored at temperatures of 80, 98, and 130 degrees, Fahrenheit, for periods ranging from six to twelve months, and then opened and examined. With the exception of beets and Irish potatoes, the products packed in metal containers and sealed in gas preserved their flavor, appearance, and vitamin content better than those sealed in air or packed in paper cartons.

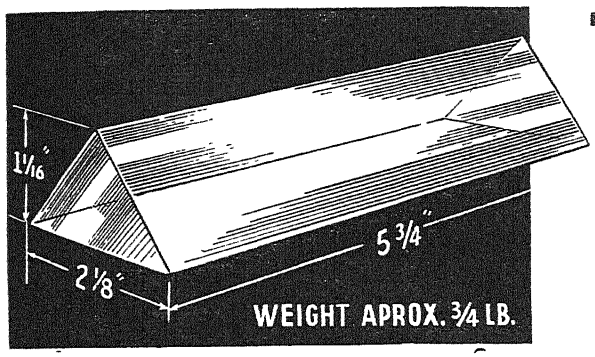
High storage temperatures, it was found, have an adverse effect upon most dehydrated foods, regardless of the way in which they are packaged. However, most dehydrated foods will retain their original quality and vitamin content with little change for periods ranging from six months to more than a year, provided they are held in an atmosphere comparatively free from oxygen and are not subjected to temperatures above 80 degrees, Fahrenheit. Foods least affected by high temperatures are hominy, beets, apple nuggets, and tomato flakes, while those most sensitive to temperature above this figure are cabbage, onions, Irish potatoes, tomato juice cocktail, and carrots.

Although these experiments indicate that gas packing in metal containers is the best way to package most dehydrated fruits and vegetables, Continental Can Company is unwilling to

SENSATIONAL WAR BARGAINS *in* LENSES & PRISMS

All Items Finely Ground and Polished but Edges Slightly Chipped or Other Slight Imperfections which We Guarantee Will Not Interfere with their Use.

The Government is urging that War Surpluses be disposed of during the war. We are making every effort to cooperate and in keeping with our low price policy on war surplus items, we are passing on to you excellent purchase opportunities at quotations substantially below cost of manufacturing. Individuals, colleges, high schools, researchers should take advantage of these bargains at once.



TANK PRISMS

In order that the tank driver shall not get shot in the face, two of these Silvered Prisms are used to make a periscope (without magnification). We have secured a number of these that are very slightly chipped, making possible their sale at a very low price. They are 90-45-45 degree prisms of huge size —5¾" long, 2⅛" wide, finely ground and polished.

Stock #3004-S SILVERED TANK PRISM — Price $2.00 each Postpaid
Stock #3005-S PLAIN TANK PRISM — Price $2 00 each Postpaid.
This one is excellent for projecting all the colors of the spectrum — a beautiful sight.

FOUR PRISMS — Special $7.00 Postpaid.

. . . This is the most sensational bargain we have ever been able to offer.

WAR SURPLUS ACHROMATIC LENSES

Stock No.	Dia. in Mms.	Focal Length	Comments	Price
6016-S	12	80 mm	Uncemented	30¢
6017-S	*12	80 mm.	Cemented	50¢
6018-S	15	41 mm.	Uncemented	40¢
6019-S	*15	41 mm.	Cemented	60¢
6020-S	18	49 mm	Uncemented	50¢
6021-S	*18	49 mm.	Cemented	60¢
6022-S	25	95 mm.	Uncemented	50¢
6023-S	*25	95 mm.	Cemented	75¢
6024-S	25	11 inches	Uncemented	60¢
6025-S	*25	11 inches	Cemented	75¢
6027-S	30	140 mm.	Uncemented	60¢
6028-S	30	64 mm.	Uncemented	70¢
6029-S	35	60 mm.	Uncemented	70¢
6030-S	36	171 mm	Uncemented	70¢
6031-S	36	178 mm	Cemented	80¢
6032-S	36	178 mm.	Uncemented	70¢
6033-S	37	51 mm.	Uncemented	70¢
6034-S	38	178 mm.	Uncemented	70¢
6036-S	39	51 mm	Uncemented	70¢
6037-S	41	57 mm	Uncemented	70¢
6038-S	43	57 mm	Uncemented	70¢
6039-S	48	11 inches	Uncemented	$1.00
6040-S	51	11 inches	Uncemented	$1.00

Free Cement and Directions included with all uncemented sets

*—Definitely available with magnesium fluoride low reflection coating. Others of these also have this coating but at time this is prepared we do not know exactly which ones. Coated lenses will be priced at 10¢ more than the prices shown above. If you want coated lenses, mark "coated" after stock number and include 10¢ extra. If no coated lenses are available on certain items, your extra payment will be refunded.

ROOF (Amici) PRISMS #5BS . . . . $1.50 Postpaid
A few chipped but most were rejected because roof angle was off trifle more than 2 seconds Excellent for most uses except for instruments of over 3 power.

Sorry . . . ROOF PRISM #5AS, priced at $2.50 each with corrected Roof no longer available.

PORRO ABBE PRISMS #3006-S . . 25¢ each Postpaid
Size 9 mm. by 17 mm. . . . another war bargain. Normal prices would be 10 to 20 times above quotation.

RIFLESCOPE LENSES Set #2000-S . . . $11.00 Postpaid
5 achromats matched by manufacturer. Cemented, ready for construction of fine 3½ power 'scope which would retail up to $50.00. A rare opportunity! Full instructions included.

LENS SET 120-S "The Experimenter's Dream" 60 lenses with 40-page illustrated booklet "FUN WITH CHIPPED EDGE LENSES" — $10.00 Postpaid.
The variety of lenses in this set will enable you to conduct countless experiments and build many optical gadgets. All our lenses are neatly packed and marked for diameter and focal length.

OUR SECOND ANNUAL GADGET AND OPTICAL CONTEST NOW ON. FREE DETAILS FURNISHED WITH ALL PURCHASES

REDUCING LENS SET #1004-S . . . . . $1.20 Postpaid
Contains a 2½" diameter and 1¾" diameter reducing lens of different powers.

50-PAGE ILLUSTRATED IDEA BOOKLET . . $1.00 Postpaid
Describes wide variety of uses for our lenses and contains much information especially designed for beginners in optics.

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make any predictions about the extent to which these packaging methods will be used after the war The company points out that the current heavy demand for dehydrated foods is due to various war conditions, such as limited shipping space and the shortage of certain materials. When these factors are removed, dehydrated foods will again have to compete with canned and frozen foods on the basis of cost, quality, and convenience of preparation.

CHARCOAL GAS FOR MOTORS

American-Made Unit Available for Motor Vehicles

INQUIRIES received by the editor during recent months reveal that there is a considerable interest in "producer-gas" units for use on motor vehicles in the United States. Such a unit, using charcoal for fuel, is now available. One of the illustrations shows a standard motor truck equipped with one of those Gasogene generators. It is stated by the manufacturer that such a truck, without motor alterations, will cover approximately the same mileage on one ton of charcoal as it would on 160 to 180 gallons of gasoline.

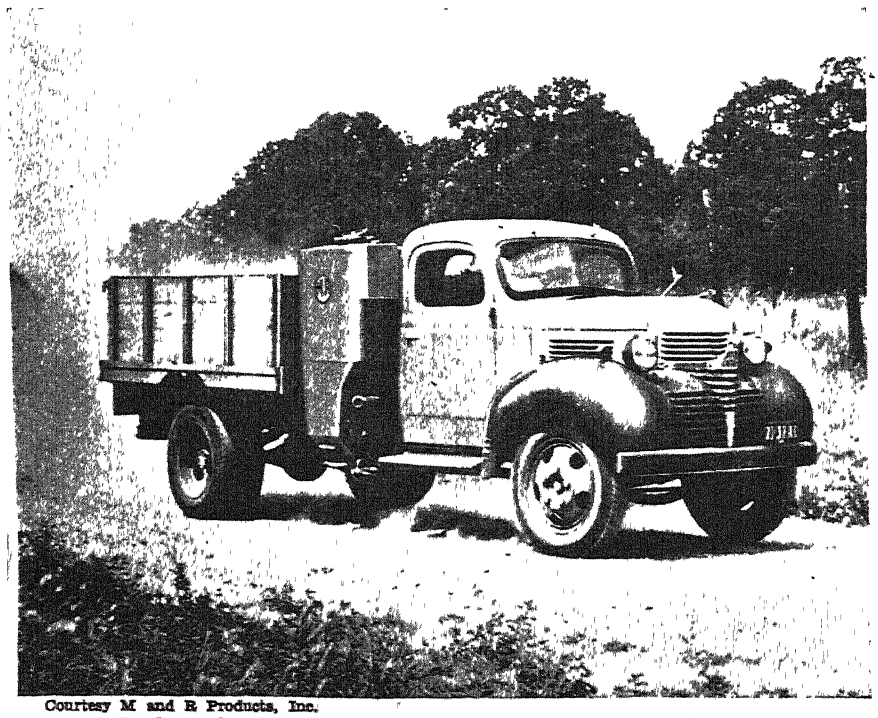
Essentially the Gasogene unit consists of a generator with a fuel storage capacity of approximately 100 pounds of charcoal. This is connected through temperature reduction and purification filters to a centrifugal carburetor where the gas and air are mixed and sent into the intake manifold.

Within the gas generator is a combustion chamber where the charcoal is burned under forced draft. The incomplete combustion results in the production of carbon monoxide. At the same time, water is permitted to drip slowly into the generator so that hydrogen is liberated and oxygen combines with the carbon The resulting gases are fed through the filtering units mentioned above and serve to operate the gasoline engine with an efficiency comparable with that of gasoline.

When a Gasogene generator is mounted on a motor vehicle, a change-over valve is installed on the intake manifold and the gasoline carburetor is attached to this valve. It is then possible to operate the motor on either fuel by a single movement of a lever It is claimed it is almost impossible to tell whether the engine is operating on gasoline or charcoal gas

While the usual procedure with a Gasogene generator is to start the engine on gasoline and then to switch over to charcoal gas, it is possible to use the charcoal for starting as well as running. When this is to be done, a hand-operated or electric blower can be used while igniting the charcoal and starting the generation of gas. It is stated that the motor can be started within 1½ to 3 minutes after lighting the charcoal.

Tests made by the United States Forest Products Laboratories show that a two-ton truck equipped with a Gasogene generator and operated over fairly hilly roads averaged a speed of 30 5 miles per hour using 1.4 pounds of charcoal per mile



Courtesy M and R Products, Inc.

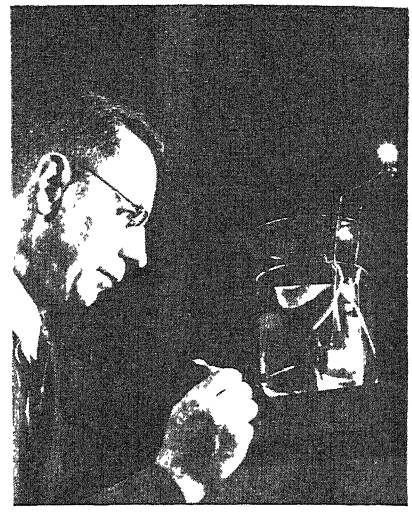
A charcoal gas generator mounted on a conventional light truck

MOISTURE-PROOF

Plastic Completely Seals Electrical Equipment

A TOUGH new moisture-proof plastic, called Fosterite, which seals radar and radio parts against harmful moisture, has been developed at the Research Laboratories of the Westinghouse Electric and Manufacturing Company. This new plastic will greatly lengthen the life of radio and other communications equipment used by Allied armies, according to Dr. C. F. Hill.

"In tropical climates where the humidity of the air is high," Dr Hill explains, "moisture seeping into electrical equipment often caused short-circuiting and breakdowns in service. Even replacement parts were sometimes made useless by moisture absorbed from the air



Plastic seals a transformer

"Fosterite is proving to be the answer to many of these problems," Dr. Hill declares. "First, because the impregnant is almost as fluid as water, it fills completely every tiny space in electrical windings and coils. Second, a special coating form of the material can be applied to the apparatus, leaving no air gaps through which moisture could seep. This happens because Fosterite, unlike varnish, requires no liquid solvent which would evaporate during the heating process and cause tiny cracks to appear."

To demonstrate the plastic's waterproof qualities, the Westinghouse scientist coated an electrical transformer with Fosterite and submerged it completely in a jar of water. An electric light bulb attached to the transformer continued to glow brightly.

"A transformer coated with ordinary materials would last only a few minutes under such conditions," Dr Hill declares. "But Fosterite-coated transformers can stay under water for weeks or even months and still give satisfactory performance"

SYNTHETIC LATEX

Offers Expanded Fields for Vinyl Chloride Resin

CREATION of a true colloidal latex of Geon vinyl chloride resin in water, without the use of any organic solvents, is a recent achievement of Goodrich research chemists, according to William S. Richardson. Sought since the first practical use of the vinyl chloride resins was accomplished by the company 17 years ago, the production of this latex will vastly expand the uses of this type of synthetics in peacetime, Richardson says. Vinyl resins, including the new latex, are under allocation by the War Production Board. Quantities for experimental use are available, however.

Adaptable to a wide variety of applications in coating textiles, wire and

other materials, and film manufacture, the latex allows all the advantageous properties of the vinyl resin to be utilized without the expense and hazards of flammable and toxic solvents necessary in older methods. It also permits use of much existing equipment which cannot handle other forms of vinyl resins and eliminates the necessity for expensive recovery systems required where these resins are applied from solution

Major potential applications of the Geon latex are in coating paper, paper board and boxboard, textiles, insulating wire, casting continuous films, treatment of glass fibers and fabrics, manufacture of gloves and other products in which rubber latex has been used, treatment of leather for added wear and moisture protection, and use in corrosion-resistant paints

Upon deposit, at the end of the drying cycle, the latex is fused almost instantaneously at temperatures of 275 to 300 degrees, Fahrenheit, to yield flexible, tough, stable, resistant coatings or films.

The new latex in clear or colored form can be brushed, sprayed, or dipped. It can be made to conform to fiber structure, thus allowing the materials treated to "breathe." It can also be applied as a flexible, impervious coating. Improved pliability, more thorough impregnation, and greater adhesion of the fibers are obtained than in older methods of vinyl resin use.

POWER TRUCK TIRES

Conserved by Care and Effective Repair

Solid rubber tires on drive and trail wheels are practically the only parts of the power industrial truck that are vulnerable to wear, and when rubber is plentiful the cost of keeping spare tires on hand for replacement is unimportant Tire life varies from three months to five years, depending on floor conditions and on the care given to the tires. However, conservation must clinch-hit for replacement during the emergency period When maximum service is obtained by making repairs before the tires have become too badly worn, rubber is conserved for other uses and trucks can be kept in operation instead of standing idle while waiting for replacements. In the plant of Warner and Swasey Company, effective methods of making repairs to power truck tires have been developed by the electrical maintenance, industrial truck department. These conservation measures have resulted in longer useful life for the tires and better operating efficiency of the trucks.

Vibration due to lumpy tires cuts down the operating efficiency of the material handling system, sometimes by inducing operator fatigue and sometimes by causing damage to the loads, such as finished precision parts. Also, tires which are out of round will wear out very much faster; and travel vibration does the truck itself no good. These are all good reasons for keeping a watchful eye on contours as well as on thickness, particularly in plants where floor conditions tend to accelerate the rate of wear

Tire wear is reduced when floors are smooth, when they are kept clean of grease, chips, metal parts, and so on, and when drivers take care to avoid hitting curbs, holes, machines, walls, columns, and similar obstructions. But with all the precautions that can be taken it is impracticable to eliminate oil and chips from some floors—nor can holes be repaired the instant they appear So a toll is taken on the tire surfaces. The principal observed causes are the deteriorating effect of oil or grease; the effect of imbedded chips, the effect of hard smashes on obstructions and pitted floors.

Tires which are subject to these excessive service conditions are seldom worn smooth. Larger pieces are dislodged from one section of the tire than from another, and the wheel goes out of round. When this condition has developed to the extent of several flat spots, a truck running at five miles an hour is subject to excessive vibration The truck handles like an automobile with a bad shimmy, and the operator naturally reduces the speed in order to preserve normal control as well as to avoid the fatigue induced by the more difficult handling

One very satisfactory method which has been developed at Warner and Swasey for reconditioning a lumpy tire is to remove the high spots by turning in a lathe, making the circumference true with the center of the wheel. Life of the remaining rubber is prolonged by

PKR-15

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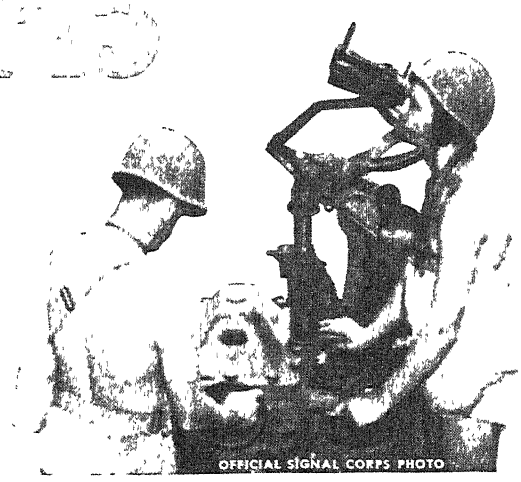
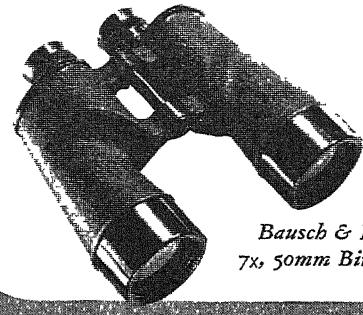
and Icy Cold



Bausch & Lomb Binoculars and other optical instruments of war serve wherever our fighting men are stationed—in tropical heat and in frigid cold, on land, at sea and in the air. To insure perfect functioning under all kinds of climatic and temperature conditions, Bausch & Lomb technicians developed many special processes and materials. One of these is a special optical cement identified as "PKR-15."

PKR-15 is a plastic-base substance used for cementing together the glass surfaces of precision lenses and prisms. Any danger of lens separation, due to temperature extremes, is eliminated—for PKR-15 will not soften in the intense heat of the tropics, will not become brittle in sub-zero cold.

PKR-15 cement is but one of many extras which mean finest binocular performance for our Armed Forces. It is another advantage you will appreciate and enjoy in your post-war Bausch & Lomb Binocular.



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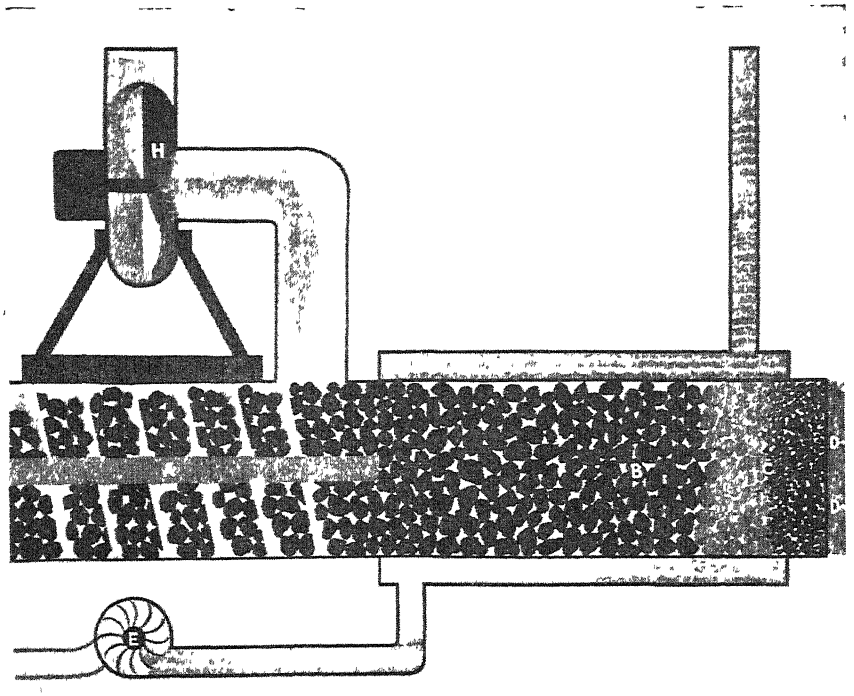


Diagrammatic drawing of new anthracite burner. Worm *A* introduces coal into the tube where it burns at *B*. Ash is discharged at *C*. Draft is provided by air entering at *D*, drawn through coal by fan *J* in smoke pipe H. Water *F* is circulated around the tube by the pump *E* and carries heat to the house through the pipe *G*

the smooth contour and more uniform distribution of load; and the efficiency of the truck is restored by enabling it to handle at normal speed. The removed rubber is not wasted because it usually has been so injured that it has no value.

In the Warner and Swasey plant trucks are used on three shifts seven days a week, and tires have a normal life of one year. After turning they run about four more months before needing further attention. After the first treatment no difference is noted in the performance of the tire. After a second cutting the tires feel a little more solid; and if a third cut is possible a still more pronounced effect of solidity is noticed. Reconditioning has been estimated to add 70 to 80 percent to the life of the tire. Care is always taken to replace tires in pairs having the same outside diameter, so as to keep the truck in a level position.

ANTHRACITE COMBUSTION

Speeded, Made More Efficient, By Application of New Principle

An economical, completely automatic, highly-compact heating unit operates on an entirely new principle of burning anthracite. Of far-reaching significance to the five million homes which now depend upon anthracite for heating and the hundreds of thousands of new homes which will be built in the post-war era, the new development substitutes a concentrated, fast-burning fire of great intensity but small size for the former method of burning anthracite slowly in a firebox of relatively large size.

Utilization of the new principle will make is possible, according to Frank W. Earnest Jr., president of Anthracite Industries, Inc., for manufacturers to produce in the early post-war period an automatic unit, suitable for heating the average sized home, that can be enclosed in a space less than two by two by three feet.

In contrast to present home heating equipment, which burns anthracite at the maximum rate of approximately 10 pounds per square foot per hour, the new development makes it possible to burn 50 to 60 pounds per square foot per hour, liberating more than 500,000 Btu per cubic foot as compared to approximately 50,000 liberated with present-day equipment. As a result, the heat absorption per square foot of heating surface is raised from 6000 Btu to 40,000 or 50,000 with a reduction in the total amount of coal consumed.

Equally effective with either hot water, steam, or warm air systems, the mechanism for applying the new principle is simplicity itself. It consists of a tube six or eight inches in diameter and approximately 18 inches long The anthracite is fed into the tube automatically; the coal burns in the center of the tube, and the ash is discharged at the other end. Water or air, circulated around the hot part of the tube in a small, compact jacket, carries the heat throughout the house in the same manner in which it is distributed by present-day heating systems.

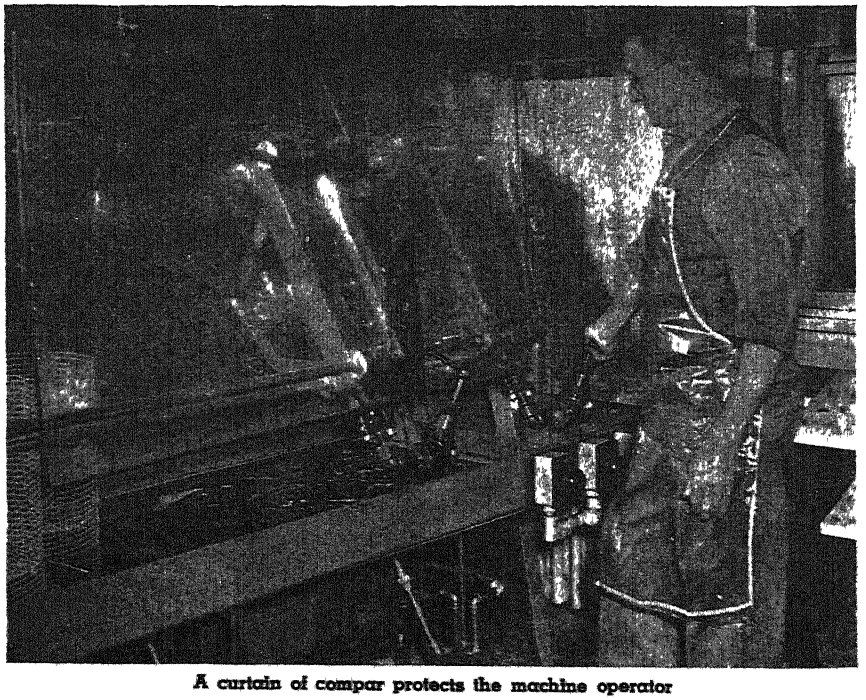
The principle is founded upon a basic characteristic of anthracite combustion which has been confirmed by research in the laboratory. Anthracite, unlike most other fuels, under proper conditions can be made to burn to complete and perfect combustion within its own area.

In adaptation to fully automatic equipment, the anthracite is fed into the tube by a conveyor leading directly from the coal supply. The ash is discharged into enclosed, dust-proof containers, which would need to be replaced only two or three times a week, or directly into pits prepared for the purpose outside the basement. The amount of heat desired is regulated automatically by thermostatic control.

SPLASH CURTAINS

Protect Machine Operators, Keeps Floor Areas Clean

For the protection of machine operators, splash curtains made of transparent sheets of compar—the flexible rubber-like synthetic developed by Resistoflex Corporation—have been tried out in a large electrical manufacturing plant in front of machines that threw oil, subjecting the operators to the dangers of oil-soaked clothing and necessitating the continual cleaning



A curtain of compar protects the machine operator

of large areas surrounding the machines. Large sheets of compar, a vinyl resin derivative that is entirely immune to oils and solvents, are mounted on frames and installed between the operators and their machines. Since the compar is completely transparent, performance of machines is visible at all times and, in addition, operators no longer are subject to skin troubles resulting from the contact of oil.

These splash curtains also are highly advantageous in testing departments where hydraulic fluids are carried under great pressure. Serious accidents are prevented in case the hose line breaks, because the great tensile strength of compar protects workers from the impact of the fluid.

INCREASED PRODUCTIVITY

Essential for Maximum Post-War Employment

JOINT action by labor and management to eliminate restrictive and inefficient practices that raise production costs is absolutely essential to assure full output and maximum employment in the post-war period, according to Albert W. Ramond, industrial engineer.

Asserting that management has long pointed to "feather-bedding," "slow-downs," and other restrictive devices of labor as contributing to economic waste, Mr. Ramond says:

"Unquestionably, there is considerable truth in this charge. Restrictive practices making it necessary to employ more men than are really needed and, consequently, increasing costs are largely a heritage of the earlier days of our industrial history. Basically, they stem from insecurity—from the fear of 'working oneself out of a job.'

"On the other side of the picture, however, there are many management practices and policies which also promote low productivity and high costs. Often, little or no distinction is made between the pay on jobs requiring a high degree of effort and attention and that on 'soft' jobs requiring only a fraction of the work or attention. Delays are frequently caused by improper planning and scheduling; wasted time and effort results from faulty tools or materials or incorrect methods of doing operations."

Such management practices, Mr. Ramond states, tend to undermine workers' morale. They discourage workers who are willing and able to do a better job, and cause workers to doubt management's sincerity in urging the need for high productivity.

"It is generally recognized by the industrial engineering profession," he continues, "that the unused manpower and equipment capacity in industry that can be laid directly at management's door adds up to a much greater total than the waste caused by 'feather-bedding' by workers. By actual measurement in many hundreds of plants, it has been found that losses in industry due to improper utilization of men, machines, and materials run from 10 percent to more than 50 percent of the available potential capacity. In some cases the losses are known and tolerated, because they are considered unavoidable. More often they pass unnoticed because management does not know they exist or does not realize their importance.

"This gap between our actual and potential industrial productivity," Mr. Ramond points out, "offers the soundest solution to the all-important problem of producing goods at low costs in the post-war era while maintaining high real wages. In the face of our extraordinary wartime production achievements, this statement may sound over-optimistic. But it must be remembered that our production results during the war were due mainly to full mobilization of productive resources rather than to a high level of productivity. We had to get things at any cost—and frequently we got them at very high cost. In the post-war period we shall have to get down to rock-bottom levels of costs.

"This will demand real co-operation between management and labor. After the war there may be a strong tendency among workers to 'spread the work' and to favor, if not to force, conditions making for higher costs. Nevertheless, I believe there is solid ground for hope in a change for the better. There are many labor officials who are convinced that increased productivity is the best way to raise real wages and living standards. It is clearly management's responsibility to support this belief, not only with words but with deeds."

Close Limits and Fine Finish -

FOR EFFICIENT PRODUCTION

Close limits and a fine finish are essential for efficient production on many important metal working operations. Maximum output at minimum cost can be attained only when the methods and machines are such that close tolerances and the best possible finish can be maintained on piece after piece, indefinitely.

It is on this type of work—exacting toolroom jobs or production operations that call for toolroom accuracy—that the high precision and dependable performance of South Bend Lathes pay real dividends. Their smooth operation through a wide range of spindle speeds produces surprisingly fine finishes. In fact, when they are installed, subsequent finishing operations can often be eliminated.

Today South Bend Lathes are better in every way. Our entire plant is devoted solely to lathe production. There has been no lowering of standards because of war-time restrictions or shortages and the use of substitute materials is negligible, being limited to non-essential parts. Improvements have been accelerated to meet war production needs.

South Bend Engine Lathes and Toolroom Lathes are made in five sizes: 9", 10", 13", 14½", and 16" swing. Precision Turret Lathes are available in two sizes. Write today for Catalog No. 100-C.

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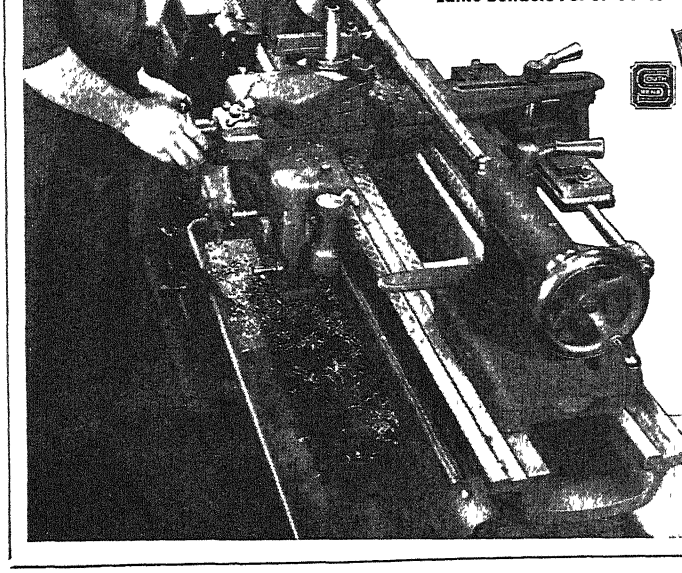


POST-WAR PRIORITY PLAN

To those who cannot qualify for a war-time priority, South Bend Lathe Works offers a practical Post-War Priority Plan. You can place your order now for any South Bend Lathe for delivery when civilian production is resumed. Write now for details of this plan.

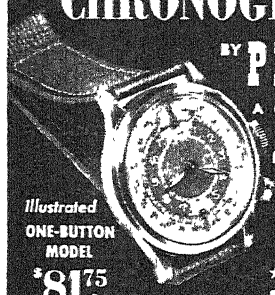
AIR CONDITIONING FIRES

Can be Prevented by Correct Design and Maintenance

AIR CONDITIONING system fires, like those of the automobile in its early days when the car which didn't burn up was usually the one which won the road race, will be largely eliminated when the causes are fully understood, says fire-preventionist John Neale, chief engineer of Underwriters' Laboratories, Inc.

"Loss of life and property has resulted from air conditioning system fires but can be prevented in the modern air conditioning system," he con-

CHRONOGRAPH
BY PIERCE



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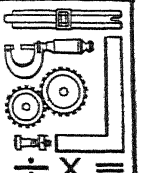

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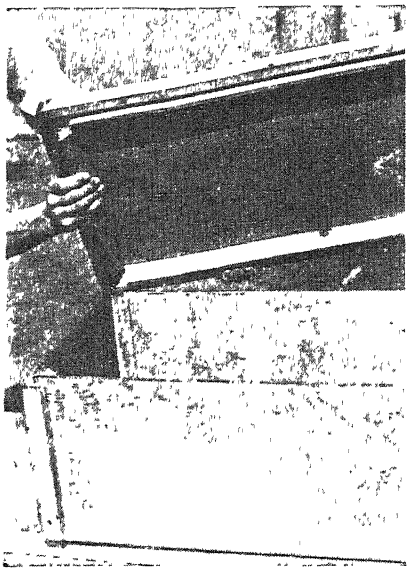


Above: A lock-joint plywood box nearly completed. Right: These boxes can be made in any mill that has the usual woodworking machinery

tinues, "by proper design and maintenance and the use of such safeguards as fire-resistive air filters tested by Underwriters' Laboratories, non-combustible ducts, fire-resistive duct linings and insulation, automatic fire shutters in the duct systems to prevent the spread of fire, and electric-eye smoke detectors coupled with alarm systems and electrically connected to shut down the system when fire breaks out.

"Smoke, as well as fire, introduces a panic hazard," Neale says. "This is particularly serious, since air conditioning systems are usually installed in public buildings where crowds are present."

Screening of the intake openings, frequent cleaning of the ducts, and proper location of the intakes well above the floor level will help prevent accumulations of all manner of combustible trash and lint in the ducts.

WOOD LOCK JOINT

Results in Rugged Plywood Boxes

CONSIDERING the great need for efficient means of packaging war materiel and the challenge of so many hazards for the packing cases now being used extensively, it is no wonder that much experimentation has been going on in the field of packaging.

One of these experiments has been carried out under the supervision of Roy Klomparens, president of the Klomparens Lock Joint Manufacturing Company. The wood lock joint was developed when shortages of metal anglebars and fastenings made it difficult to manufacture rectangular ducts for air-conditioning. It was only a step from the lock-joint principle in manufacturing the ducts to the development of a lock-joint plywood package to be used in transporting war supplies. Parts of this type of joint are a small-diameter rod (made of wood, metal, fiber, or other available material) and two grooves of semicircular cross-section—one cut parallel with the edge of a flat piece of plywood or other material; the other cut within the slot of a piece of wood or metal corner framing. When the flat piece is thrust into the slot of the framing, the two grooves come opposite each other, forming a long circular hole into which the rod is slipped to lock the parts together.

Not only does this method save time and cost of assembly, but the lock-joint boxes may be manufactured in any mill which has the usual woodworking machinery. The lock-joint package has been tested for strength and ruggedness

at Rockaway Package Research Laboratory and at Forest Products Laboratory. Strongest parts of the boxes are the corners, it was discovered. The boxes were tested with a sand load on a rough-handling wheel where they went through 3567 falls before being demolished.

FINE DUSTS

Prove the Undoing of Many Insects

NEW studies of extremely fine dusts that kill costly insect pests by making them thirst to death are reported in *Chemical and Engineering News*. Coal ash clinkers, it was found, are one ready source for such a dust—nonpoisonous but lethal in a different way—which kills grain weevils, an insect destroying some $3,000,000 worth of grain annually in the United States alone.

Dusts likewise are effective against the rice weevil, flour beetle, Mediterranean flour moth, fig moth, cocoa moth, meal worm, saw-toothed grain beetle, spider beetle, and bedbug.

The studies were made by Dr. H. V. A. Briscoe of the Imperial College, London, and his associates. They were seeking new facts about an old story, for the use of dusts to kill weevils probably was known to the Egyptians some 4000 years ago.

These inorganic or chemically inert dusts do not kill by affecting the digestive or bronchial organs of the insect, they proved, but by the action on the outside casing or skin of the weevil.

This casing or epicuticle holds the moisture needed to maintain the insect's water balance. Apparently the coating of dusts keeps out enough water so that this balance breaks down The insect literally dies of thirst

Silica dust has been most generally used as inert and non-toxic. Very fine diamond dust, cleaned and purified repeatedly, proved far more effective in killing weevils than any dusts previously tried. Carborundum dusts likewise were extremely effective.

To be practically useful, the report of Briscoe's work said, a dust must be very hard, very fine, should not contain free silica with a risk of silicosis for workers, and raw materials must be reasonably cheap and plentiful.

The most suitable material was tentatively found in coal ash clinker.

Particle size and distribution are particularly important, since particle size governs the degree of adhesion of the dust. The harder the dust particles, the more effective they are.

The English workers developed a method of testing dusts, and also established that wet grinding is essential in preparation of the material. In dry grinding, there is greater friction, and this apparently rounds the corners and polishes the surfaces of the dust particles, making them less effective.

CAST BUTTONS

Made of Plastics by New Technique

BUTTONS made of plastic by casting are being produced by a technique which, together with determinations of the most suitable materials, have been worked out in the laboratories of Sam Tour and Company, Inc, engineers and consultants

It has been established that buttons can be made in attractive designs suitable for various types of ornamental finishes, at costs that compare favorably with older methods of manufacture, using materials available in quantity.

SILICONES

Developed to Provide Heat-Resisting Insulation

SAND, brine, coal, and oil are providing the basic elements for opening a new field of chemical manufacture to produce silicones, materials of far-reaching industrial performance.

In revealing the performance of the first commercial production of these silicones, W. R. Collings, Vice President and General Manager of the Dow Corning Corporation, states that they are the result of research to utilize silicon and oxygen, the elements of which sand is essentially composed, in the production of new temperature-resistant materials. "Among the most important of these silicone materials," says Mr. Collings, "are high temperature insulating resins, but silicones can be produced either as solids or liquids in an indefinite variety of forms.

"Silicone chemistry makes possible the building of lighter and better electrical equipment for the war effort, for the home, and for the factory," Mr. Collings states. "Exhaustive tests by engineers of the Westinghouse Electric and Manufacturing Company have brought reports of unusual success in the use of silicone insulating materials.

"An outstanding result attained in the electrical industry is the special instance in which Westinghouse engineers redesigned a three horsepower motor to provide an output of ten horsepower by using high temperature resistant silicones for the electrical insulation"

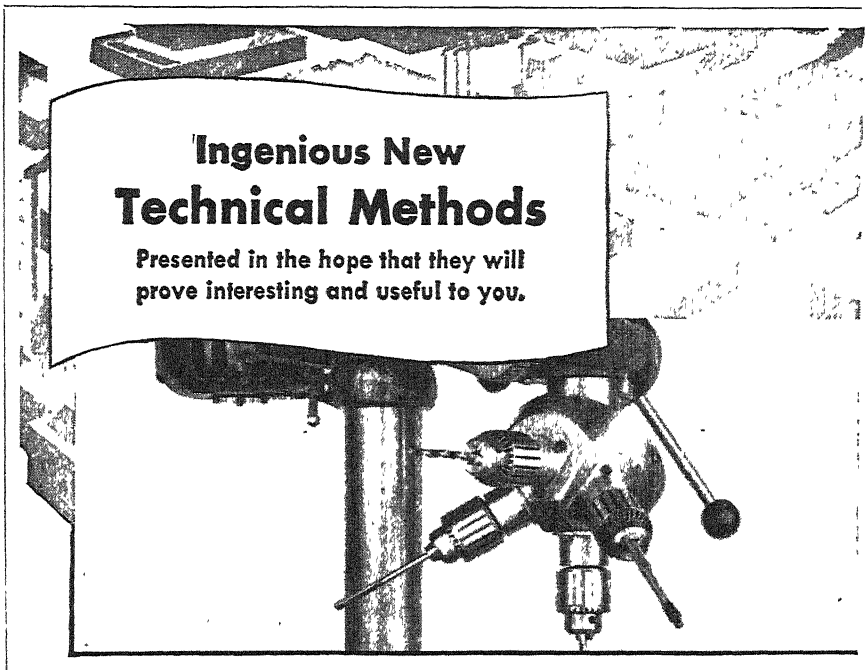
The first of these silicones was developed by research scientists of the Corning Glass Works in their search to find suitable coating resins for use with glass fibers for electrical insulation or for other purposes where high temperatures are likely to be encountered.

Where ordinary insulation varnishes consist of carbon and hydrogen—a combination known to be inflammable—this new insulation is formed into resins and varnishes by a union of silicon and oxygen. It is the inherent stability of this combination of elements that is yielding products of exceptional heat resistance.

COLLAPSIBLE TUBES

Can be Made from Transparent Thermoplastic

SHAVING cream and toothpaste in attractive colors after the war are possibilities as a result of the adaptation of Goodyear Pliofilm for collapsible tubes. Pliofilm is a thin, thermoplastic sheet with a rubber base, which can



Amazing New Four Spindle Turret Attachment for Drill Press!

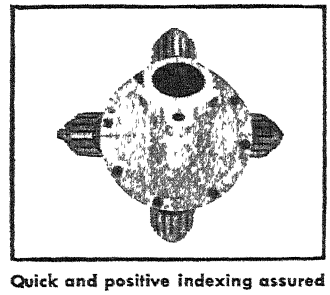
Now one drill press can do the work of four and, at the same time, effect a savings of up to 75% in floor space, with the "Quadrill" attachment. This rotary device will accommodate four boring or cutting tools at the same time, yet one tool *only* is in motion when the head is in operating position.

The entire unit is assembled to the quill of the drill press and is driven from the drill press spindle. Accuracy and rigidity of alignment of the "Quadrill" are assured by the special construction of the driver and spindles, thus efficiency is only limited by the accuracy and power of the drill press itself.

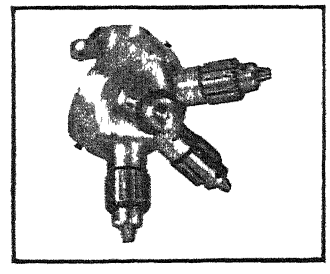
Foolproofing in indexing is accomplished by visual markings and by the relationship of the index pointers on the index disc, as well as the extension of the spring retainer. Four hardened and ground spindles are fitted for No. 32 Jacobs chucks or their equivalent. To provide correct positioning at all times, the entire spindle assembly is located by means of an accurate fitting of recess and undercut, between turret and bearing housings. The hardened friction starter and driver have been so constructed that at any speed proper synchronization of the driver teeth is accomplished without clashing.

It goes without saying that our fighting men must have the finest possible quality materials home industry can produce. So, although the stock of quality raw materials from which Wrigley's Spearmint chewing gum is made is growing steadily smaller, they are still maintaining pre-war standards. However, they can now make only a portion of their former output, so all of this limited production is going to our fighting men and women overseas only . . . where it is an "on-duty" need.

You can get complete information from Chicago Drillet Corporation, 919 N. Michigan Ave., Chicago 11, Ill.

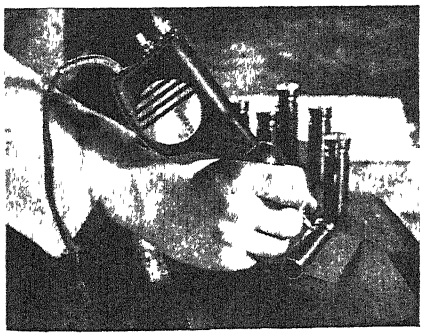


Quick and positive indexing assured by pointers on index disc



Quadrill assembly complete ready for attachment to drill press

Y-140



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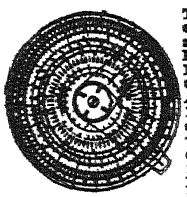

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be produced in transparent as well as in colored form. Thus post-war shaving cream, toothpaste, creams, lotions, and similar materials may be produced in various shades and packaged in transparent Pliofilm to distinguish them from one another in medicine cabinets and closets.

Other advantages which Pliofilm is said to hold over current materials, such as lead-sheathed tin for collapsible tubes, include resistance to ingredients in many substances which deteriorate the metal used in current and pre-war collapsible tubes. Also, Pliofilm is economical and lighter in weight and is as readily printed or otherwise identified as other materials.

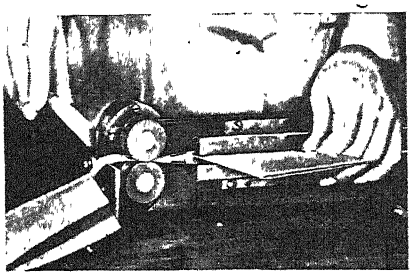
Collapsible tubes are made by wrapping strips of Pliofilm spirally into a heat-sealed tube. Then the Pliofilm is heat-sealed at the bottom into an integrated bond.

PACKAGE SEALER

Creases Tape,

Closes Package

PARTS packaging at the Studebaker military truck plant has been greatly



Sealer for flat packages

speeded up by the introduction of a sealer for flat packages of gasket sets. In the original practice, girls were called upon to crease acetate tape by hand around the open edges of the packages. With the sealer, an operator merely inserts the package edges at right angles to the flat face of the tape and turns a crank. Movement of the crank draws the tape and package between two rollers. The rollers form the tape into a closing lip which seals the opening. At the completion of the process, the tape is clipped.

PROCESS CONTROL

Urged on Vital

Casting Industry

COMPILATION of basic engineering data on process control procedure in the manufacture of malleable, gray iron, and steel castings, begun months ago by SAE War Engineering Board, now promises to aid in establishing process control in every plant as a preventive method of policing manufactured processes and of reducing the excessive rejections and large-scale scrap losses which currently are the greatest barrier to increased output.

Urging close co-operation, from design to completion of castings, the recommendations suggest analysis of every detail and phase of manufacture in the individual plant, preparation of plant production manuals, and rigid adherence to the specifications thereafter. Proper inspection and selection of raw materials, segregation of scrap, proper operation of furnaces, cupolas, and other equipment, and repeated quality control checks additionally are recommended.

The problem of increasing foundry production is regarded as one calling not only for increased manpower, but for changes in operating methods to assure satisfactory production of complicated castings.

PLYWOOD BOX CARS

Are About Two Tons Lighter

Than Conventional Cars

THE Great Northern Railway recently dispatched to the Pacific Northwest a freight train containing 100 cars made partly of plywood. Use of plywood cuts about two tons from the weight of an average conventional box car. The new cars were the first of 1000 being built in Great Northern shops in St. Cloud, Minnesota. They are painted a bright orange to distinguish them from standard box cars. The understructures and frames of the new cars are built of steel and lumber, but plywood is used for the inside and outside sheathing.

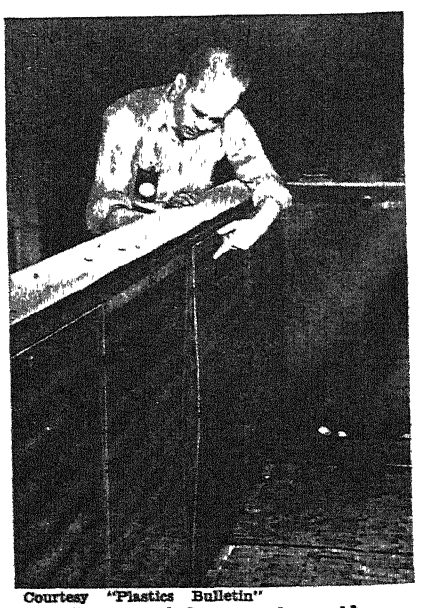
TANK LINING

Made from Plastic for

Electroplating Use

SO successful has been its experience with tubes of Lucite methyl methacrylate resin for insulators in their electroplating baths, that a leading aircraft plant has now installed transparent sheets of the same plastic for the lining of its anodizing tanks used in the electroplating operation. The sheets of plastic insulate aluminum alloy aircraft parts from the metal sides of the 28,000-gallon tanks holding chromic acid and anodizing solutions.

The use of Lucite has extended the life of the tank linings indefinitely,



Courtesy "Plastics Bulletin"
Lucite tank lining resists acid

since it is not affected by sudden temperature changes and by the 15 percent chromic acid solution. Plant officials report also that Lucite has proved less expensive, less subject to breakage, lighter, and easier and safer to handle than the material previously used Lucite tubes used for protecting parts in the electroplating bath are credited with doubling plating output at this plant.

ICE FOR SURGERY

Mechanically Produced in the Tropics

REFRIGERATION anesthesia, a technique in surgery that is said to be bloodless and shockless, is being used successfully on the battlefront by units of the Navy's Medical Department attached to Construction Battalion detachments in the South Pacific. This was revealed when medical officers recently returned from that area listed the new method among the various medical uses of flake ice in the tropics.

The flake ice required for anesthesia, known also as "cold surgery" and as "protoplasm anesthesia," is made available, at the flick of a switch, by ice-making machines developed for peacetime use by the York Corporation. Because the machines, called "FlakIce," are self-contained, portable, and are capable of producing ice within 60 seconds after being connected to the power source, they have proved especially suitable to the wartime needs of Seabee detachments in isolated island outposts. Utilizing stored water or any available local supply, the ice makers can produce a ton of flake ice every 24 hours. At least one such machine is allotted to every 250 Seabees.

In addition to its use in anesthesia, other medical uses of flake ice reported by the Navy include general treatment of face and head wounds, reducing fevers and swellings, and relieving pain. Moreover, the flakes have numerous other applications important to Seabees' health, comfort, and general welfare.

FILM STORAGE

Air Conditioning Protects Sensitive Photographic Materials

VALUABLE film and photographic papers are protected from the deleterious effects of excessive temperature and moisture in the atmosphere by means of an unusual application of air conditioning at the Orlando Airfield. One Chrysler Airtemp packaged air conditioning unit used to maintain a temperature of from 65 to 70 degrees was installed by the H. A. Daugherty Company to serve a small room used for the storage of sensitized materials.

Many air fields use domestic refrigerators for the storage of film. These boxes are designed to operate at approximately 50 degrees, Fahrenheit, which has been found to be too low a temperature for satisfactory film storage.

At the Orlando Airfield a small room was constructed, insulated, and equipped with slatted shelves. The Air-temp unit was equipped with reheat, spray type humidifier, and installed to operate with both temperature and humidity control. Design temperature of 70 degrees, Fahrenheit, and 50 percent relative humidity has been found to be satisfactory for this service.

SELF-VULCANIZING

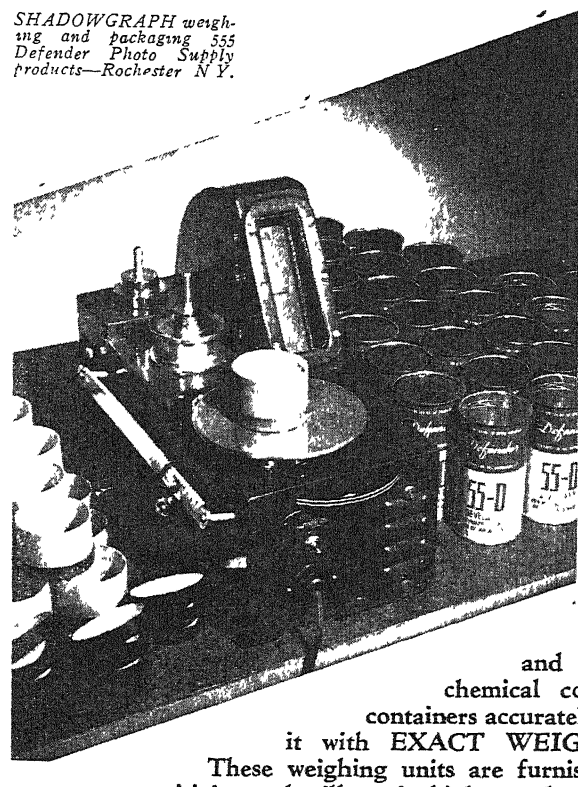
Synthetic Rubber Promises Myriads of Uses

DEVELOPMENT of a liquid synthetic rubber that promises to open vast new fields of application for rubber-like materials is announced by the Thiokol Corporation, manufacturers of America's first synthetic rubber. Designated LP-2, the unique polymer is 100 percent liquid synthetic rubber. It has no water or solvents and can be cured in controlled periods of from 10 minutes to 24 hours without heat or pressure by the simple addition of chemical vulcanizing agents.

Combining the excellent low-temperature flexibility and solvent, ozone, sunshine, and aging resistance of other high-grade synthetics, the new rubber is particularly noteworthy for its ability to set without shrinkage at room temperature.

Application possibilities for this new material are expected to be almost limitless. Because it does not shrink when set, LP-2 offers an excellent filling material in the isolation of parts against vibration or from one another, particularly in the electrical field. As a

SHADOWGRAPH weighing and packaging 555 Defender Photo Supply products—Rochester N Y.



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Here's how to weigh and package high-priced chemical commodities in small containers accurately and profitably. Do it with EXACT WEIGHT Shadowgraphs. These weighing units are furnished in unbelievable sensitivity and still retain high speed production. They are expressly designed to give users the highest degree of accuracy under present day industrial demands for volume production. Shadowgraph scales are electrically operated, simple in construction, easy to use, and trouble-free. No matter what you package in small containers Shadowgraph will handle your work.
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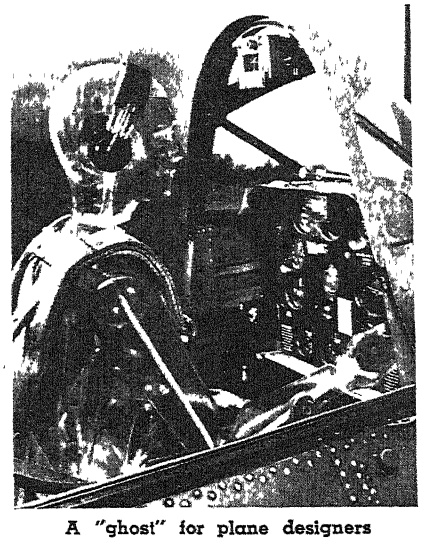
sealant and caulking compound for pressurized airplane cabins, integral wing fuel tanks, solvent containers, and the like, LP-2 has already proved its effectiveness together with a rapidity and low cost of application that surpass other materials. In coating formulations, it offers an excellent gasket and paper or cloth container coating, particularly in building a heavy coating or where solvent resistance and low-temperature flexibility are required Printing rolls, valve seat disks, plaster molds, and a broad variety of other objects can be formed from this liquid rubber A wide number of post-war consumer uses are also seen.

MANIKINS

Aid in Design of Airplane Interiors

PLASTIC "ghosts" which are mathematically accurate averages of the trim feminine dimensions of the WASPS are now enabling designers to make correct adjustment of plane interiors and equipment so that the girl flyers can operate safely and efficiently in quarters primarily scaled to the bulkier male dimensions of the United States Army Air Forces The transparent life-size manikins made of Du Pont "Plastacele" cellulose acetate plastic are sculptured to dimensions representing composites of the measurements of all the members of the WASP.

The manikins are made in sections and the mechanical action of each joint is reproduced by means of elastic "tendons" making possible "in action" studies of operating space requirements even though the plane is on the ground.



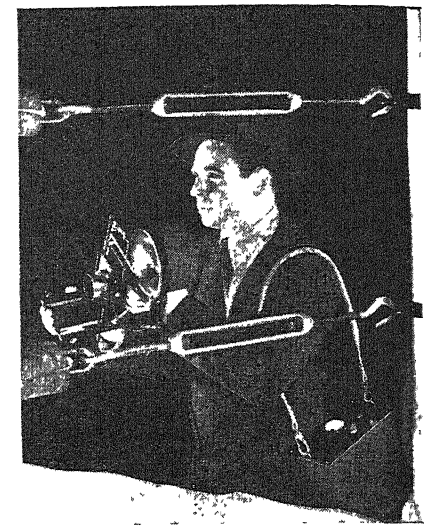
A "ghost" for plane designers

Being transparent, the manikins afford a clear view of points of contact. Applications are foreseen for the principle in post-war planning of automobiles, furniture, and personal equipment.

PORTABLE SPEEDLAMP

Will Stop Action At 1/5000 of a Second

IT'S HERE and for use by the armed Services, but for civilian photographers and other "lens artists," unless they rate a high priority, it is one of those "things to come." With most of the limited production going to the government, Eastman Kodak Company is releasing the new Kodatron portable Speedlamp which, with its ability to stop extreme, dramatic action, has been one of the favorite dreams of press photographers, especially for indoor sporting events.



High speed portable photo lamp

This Speedlamp offers in compact, portable form, a flash outfit capable of making about 200 consecutive flashes when the battery of the power unit is employed, or an indefinite number of flashes when operating with a standard A.C. circuit. The power unit, which weighs 18 pounds, is supplied with a shoulder strap for convenient and rapid transportation

The light output is sufficient to produce a fully timed negative of an average subject at 15 feet with high speed film, exposed at *f*/11. The flash itself has a duration of about 1/5000 second, a speed far above that of any mechanical shutter. The only time lag involved is the time that it takes to change the film.

Production is limited and deliveries can be made only after government requirements are fulfilled, and then high priorities are necessary with deliveries subject to availability.

OIL SHORTAGE

Not Likely if Research and Technology Are Unhampered

THERE WILL be no shortage of oil in this country if research and technology are unhampered by regimentation, Dr. Robert E Wilson, president of Pan American Petroleum and Transport Company, says in *Chemical and Engineering News*.

"The only thing that can prevent our country from having abundant liquid fuel for many generations, at reasonable prices—certainly much lower than those of 25 years ago—is interference with the free play of technology and competitive enterprise," Dr. Wilson declares.

The most convincing demonstration of the industry's faith in the future of petroleum, he points out, is that since

the outbreak of war the petroleum industry has invested about $525,000,000 of its own money in new refinery equipment to meet war needs.

"The most serious and imminent danger to the future of the industry is not the possible shortage of satisfactory raw material, but lies in certain threats to the future of the very research and technology which is the indispensable multiplier of our natural resources" Dr Wilson asserts.

"Demands in certain quarters for regimentation and government domination of research, if yielded to, could easily devitalize our whole research program. Equally serious are the attacks on our patent system, without which we would not only lose much of the incentive to research, but most of those who did continue their research would revert to the dark ages of secret processes and cease prompt publication of their discoveries. Such action would tremendously retard the progress of science."

This is by no means the first time that this country has been concerned about the future of its crude petroleum reserves, Dr. Wilson says. At the close of World War I, he recalls, the total recoverable reserve was estimated to be about 6.5 billion barrels.

"Since 1918 cumulative production has totaled 23 5 billion barrels," he adds "And yet we had, at the end of this 25-year period, really proved reserves in excess of 20 billion barrels of crude oil. The miracle of feeding the multitude with five loaves and two fishes, with twelve baskets left over, seems to have a modern counterpart! Small wonder that geologists have ceased trying to estimate any limit on the amount of oil which may yet be discovered."

The "feast or famine" characteristics of the petroleum industry before the general adoption of conservation on practices in crude production caused it to be regarded for many years as highly speculative, Dr. Wilson continues.

"Lord Curzon and others gave the petroleum industry a large share of credit for winning the previous war However, our daily output of gasoline for military use in this war is running about 18 times as great, and that of aviation gasoline about 80 times as great, as in the last year of World War I, and the improvement in quality is equally amazing."

Undoubtedly the greatest single factor in improving our oil-finding technique has been the development of geophysical methods of locating underground structures favorable for the trapping of oil, Dr. Wilson says.

"Of fully equal importance from the standpoint of getting the most out of our natural resources, have been the amazing developments in refinery technology since 1918.

"The outstanding development of recent years in this field is catalytic cracking, the giant towers of which dominate the landscape in most of our refining areas.

"Cracking is, however, only one of many processes which have made important contributions to the yield and quality of modern motor fuel. Polymerization processes now make possible many thousands of barrels daily of high-quality gasoline from refinery gases which in the past were wasted or burned as fuel.

"Hydroforming, hydrogenation, isomerization, and many other additions to the family of chemical processes used by our refineries, have come out of our research laboratories to make major contributions to the air superiority which is so largely responsible for our present situation in the war.

"Tetraethyl lead is another outstanding development of the past quarter century making for better anti-knock gasoline. That single invention increased the available horsepower of the automobile engines made in the year 1941 by an amount equal to 75 Boulder Dams!

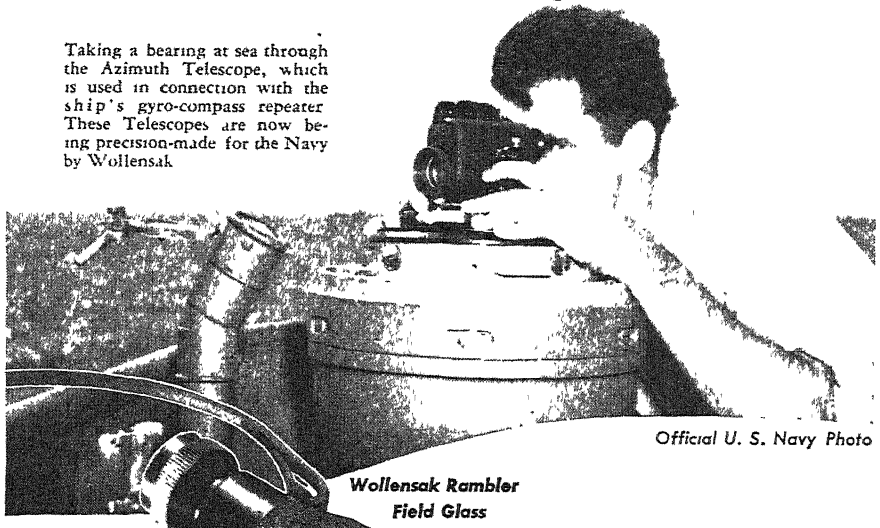
"Despite the outstanding accomplishments of the new oil-finding and producing techniques, if it had not been for the developments in refining technique we would today have barely half enough crude oil to meet our gasoline demands, and the quality would be such that modern automobiles could not even operate, let alone modern airplanes"

TELEVISION RELAY Points Toward Post-War Networks

MUCH of the fundamental work to form the basis for the post-war televi-

Wollensak means Good Lenses

Taking a bearing at sea through the Azimuth Telescope, which is used in connection with the ship's gyro-compass repeater These Telescopes are now being precision-made for the Navy by Wollensak



Official U. S. Navy Photo

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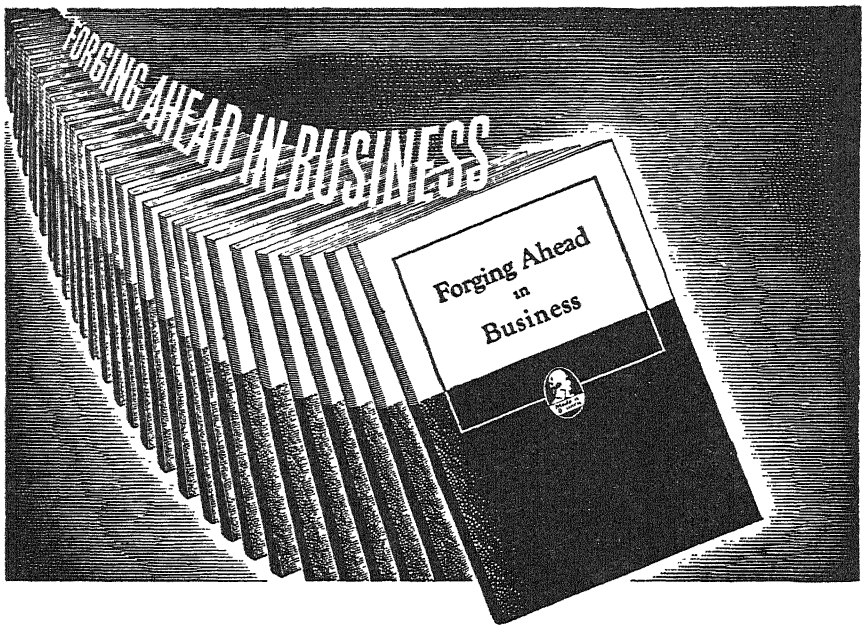

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Among the prominent industrialists who assisted in the preparation of the Course, which is described in "FORGING AHEAD IN BUSINESS" are: Alfred P. Sloan, Jr., Chairman of the Board, General Motors Corp.; Thomas J. Watson, President, International Business Machines Corp., and Frederick W. Pickard, Vice President and Director, E. I. du Pont de Nemours & Co.

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Frankly, this booklet has no appeal for the immature mind. It does not interest the man who, for one reason or another, is wholly satisfied to plug along in a mediocre job. But, for the alert, future-minded individual—the man with ambition and "drive"—"Forging Ahead in Business" has a message of distinct importance. If you feel that it is intended for you, don't hesitate to send for a copy today. Simply fill in and mail the coupon below.

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sion industry has now been completed, and over the years television should duplicate and indeed surpass the remarkable record of growth and progress of radio, it is predicted by John Ballantyne, president of Philco Corporation.

"When television standards have been established by the Federal Communications Commission and the materials situation eases to the point where new equipment can be produced, television promises to grow rapidly in public esteem and popularity," Mr. Ballantyne believes.

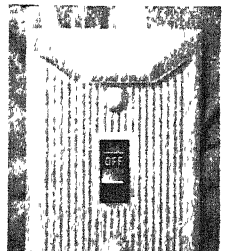
A New York to Philadelphia television relay transmitter link, connecting the two cities for video broadcasts, has already been officially dedicated. This new link, installed near Princeton, New Jersey, replaces previous experimental installations and marks the beginning of the first regularly scheduled television relay system capable of providing commercial service in the United States

"The new television relay, developed by Philco engineers, is the first of its kind, and is capable of providing dependable, high-quality service at all times and under all atmospheric conditions," Mr. Ballantyne states. "It is entirely possible that similar links, which can be constructed at a cost of about $15,000 each, located approximately 50 miles apart, may form the basis for a nation-wide television system in the post-war period."

SWITCH PLATE

Is Illuminated When Lights Are Out

An electrically lighted wall switch plate that operates for less than two cents a year and adds materially to the utility and convenience of ordinary light switches, has been introduced by the Associated Products Company. Known as the LumiNite wall switch plate, it



Built into this switch plate is a small electric light bulb that is always "on" when the switch is "off"

features a tiny shielded light that comes on automatically when room lights are turned out, and remains off whenever room lights are burning. Thus it not only makes the switch easy to locate in the dark but also serves as a safety or pilot light at night, and helps keep walls free of smudges and fingerprints from hands groping for light controls.

Another important advantage of the LumiNite plate is that it saves on light bills by indicating whenever porch, basement or upstairs lights that can't be seen from the switch location have been inadvertently left on, either in the daytime or at night. It should have equal advantages in many shop locations.

New Products

VAPOR LAMP

A NEW modulating light consisting of a high-pressure mercury vapor lamp with associated controls has been developed in the research laboratory of Hanovia Chemical and Manufacturing Company. The new lamp provides "a perfectly steady light as a source for printing sound track on film." The controls, it is announced, "automatically adjust the light intensity to various levels for printing photographic films, especially those used in motion pictures."

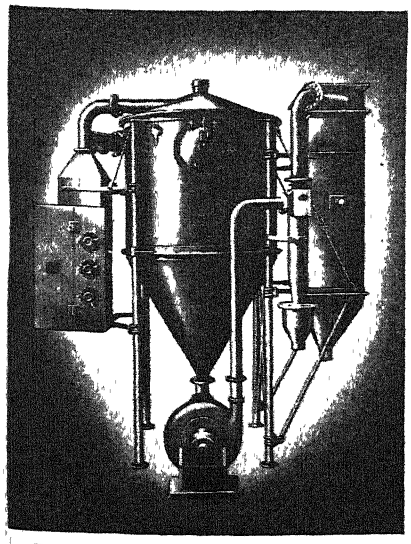
Created on demand of the motion picture industry, the new device has other applications in the fields of photofinishing and of processing microfilm, where a steady light source whose intensity can be readily controlled is a definite requirement.

Electronic control of the light is provided through the use of electronic tubes and photoelectric cells so arranged that film densities automatically change light intensity as required

SPRAY DRYER

To MEET an increasing demand for an inexpensive small-capacity spray dryer for the commercial drying of high value products, for use in laboratory research, and in pilot plant operation on specific materials, Western Precipitation Corporation has announced development of the Type N Turbulaire spray dryer.

This versatile unit offers a number of important advantages for drying products such as fine chemicals and pharmaceuticals, and for investigation of spray drying problems. Standard equipment includes electric heater, four foot desiccator with cone bottom and hand-operated mechanism for sweeping surface accumulations from the conical section, Multiclone collector, fan, bag house, and control instruments mounted on a single frame for maximum compactness and ease of installation. Only electrical, compressed air and feed line connections need be made.

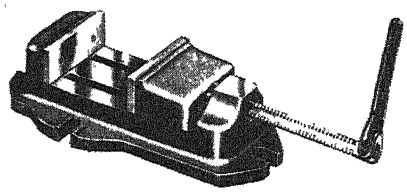


Dryer for laboratory or pilot plant

The desiccating chamber is provided with a secondary inlet for introducing tempering air at inlet temperature, or precooled to any desired temperature This permits investigation, for example, of the dryability of thermoplastic and heat sensitive materials as well as those having a tendency to case-harden.

HEAVY DUTY VISE

A FAST locking heavy duty vise of radically new design, developed by the Mechanics Engineering Company, is set and released by means of a Bar-Lok



Operates on a quarter turn

push-pull pressure unit This has a positive locking contact at four points and will develop pressure up to 20,000 pounds Only a quarter turn of the handle is needed to lock and release. The Bar-Lok vise is precision built for heavy duty, especially around milling machines and drill presses and wherever severe vibration might affect holding

LOW PRESSURE GAGE

DEVELOPED by Wallace and Tiernan Products, Inc., a new gage is so sensitive that it will register the pressure exerted by a head of 0.02 inch of water. Developed for use in aerodynamic testing and research, the gage has numerous applications in the processing industries, as well as in many different kinds of laboratory work where it is necessary to make accurate measurements of gases and liquids at low pressures.

This new gage, sensitive to one part in 500 and accurate to one part in 300, possesses a number of novel features Backlash has been eliminated by an ingenious method, so that the action of the extremely sensitive series-connected beryllium copper capsules, which serve as the pressure sensitive element, is transmitted to the pointer with maximum accuracy.

This precision low pressure gage can be furnished to cover a pressure range as low as 10 inches of water, and the 330-degree scale may be calibrated to meet any need. Gages can be con-

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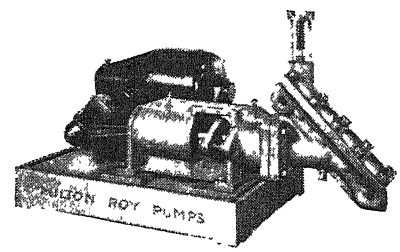
STEP-VALVE PUMP

DESIGNED specifically for controlled volume against negative differential pressures, a new step-valve pump retains all the essential features of the Milton Roy double-ball check valve



Pump parts are completely accessible

Outside spring-loading provides ready adjustment for desired load The single cover plate is readily removable and provides complete accessibility without disturbing intake or discharge piping. This valve affords complete freedom from air-binding. There is minimum restriction of passages since the pumped liquid moves in an almost straight line under the ball checks, not around them.

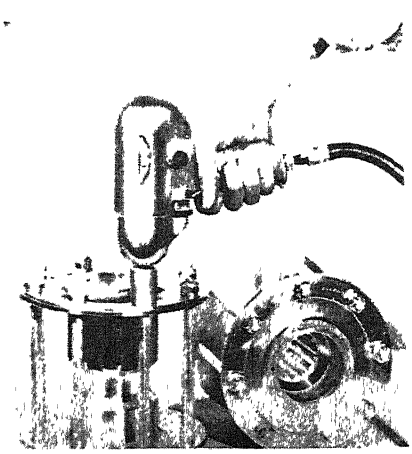
This type is supplied for pumping viscous materials such as liquid latex, acid sludges, tars and asphalts, salt slurries, and textile fibres in suspension.

IMPACT WRENCH

OPERATING with controlled torque, a new 3/8" impact wrench is announced by The Aro Equipment Corporation This pneumatically powered tool, which the manufacturer says completely prevents stretching or "burning" of threads, is capable of both forward and reverse rotation and has a calibrated adjusting screw on the side of the motor that enables the operator to set any bolt or nut to any desired tension.

The control is obtained primarily through the construction of the roller clutch impacting mechanism, which consists of only four major parts—anvil, hammer, and two cylindrical steel rollers When in operation, the centrifugal force throws the two steel rollers out against the hammer where they are caught in shear between the hammer and anvil members. This transfers the full torque through to the work in the form of a sudden impact

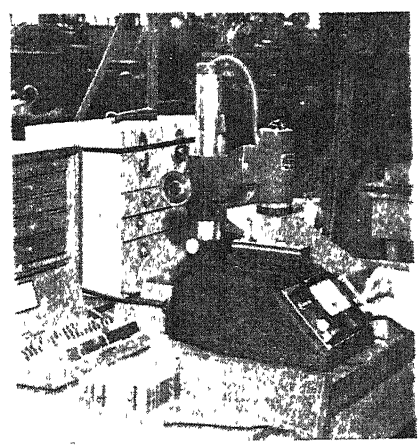
When the selected torque is obtained, the rollers rebound from the anvil face and do not allow the hammer to engage for impact. This method of impacting prevents any stretching of the threads and guarantees maximum torque By the same token, in removing nuts or bolts, there is no "burning" of the threads.



Reversible impact wrench

COMPARATOR

THE BASIC feature of the new DoAll Comparator is its wide range of magnification, which enables one comparator to do the work which formerly required as many as four standard comparators To accomplish this, each DoAll Comparator has four magnification ranges, enabling work to be checked over a wide range of tolerances. For example a work piece may be checked with the comparator to determine size variations as small as one millionth inch, and on the same comparator, a work piece can



Does the work of four comparators

be checked to determine size variations as great as four thousandths inch.

The spindle of the new comparator is equipped with variable pressure adjustment to provide the exact pressure required for measuring thick or thin sections, as well as for hard and soft materials. The spindle pressure is readily adjusted by a calibrated dial located at the top of the unit

The spindle movement is magnified electrically. This assures exact repeat readings, since there are no moving parts which could cause the spindle to stick or bind. The spindle head is provided with an adjusting collar for raising the spindle to accommodate the work, also with a hair-line adjustment knob for setting the indicating pointer on the comparator dial. The gage head swivels 360 degrees in horizontal and vertical planes, making it simple to check irregularly shaped parts or multiple jig fixtures. The protractor provided shows the angle to which the gage head is tilted. The gage head can be re-

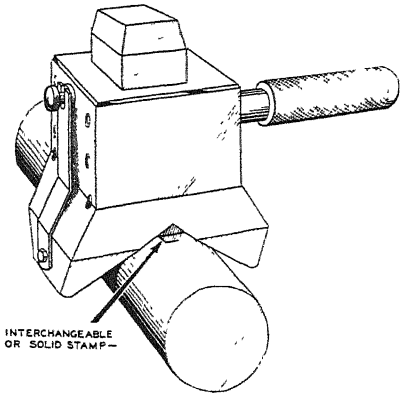
moved from the stand and used on a surface plate, machine tool, multiple gaging fixture, or for any other special application.

NEEDLE PYROMETER

QUICK and accurate temperature determinations are possible with the Cambridge needle pyrometer, which was originally designed to obtain subsurface temperature of rubber and plastic masses. This needle pyrometer however, has now found a new and very important use in determining the temperature of preforms heated by high-frequency current when either thermo-setting or thermo-plastic materials are used. A reading is obtained instantly upon insertion of the needle into the preform. Thus a means is provided for adjusting the time-cycle of the preheater for close temperature control. The instrument may also be used in checking the uniformity of heating throughout a single preform

ROUND BAR MARKER

A UNIVERSAL marking device for stamping numbers and letters on round shafts, announced by New Method Steel Stamps, Inc., consists of a single vee block which serves to hold the actual stamping device—using either solid or interchangeable type—and automatically centers the stamps on the bar being marked so that all numbers will be stamped in line and with equal clarity



A knurled stud, held tight by a flat spring, fits into a slot which is machined in the shank of the solid stamp or type holder. In this manner, the stamp possesses the necessary amount of vertical play but is kept firmly in line in all other directions since the shank is finished to a smooth sliding fit in the holder. A knurled handle permits this shaft marker to be held firmly in place on the bar stock while the actual stamping is being done

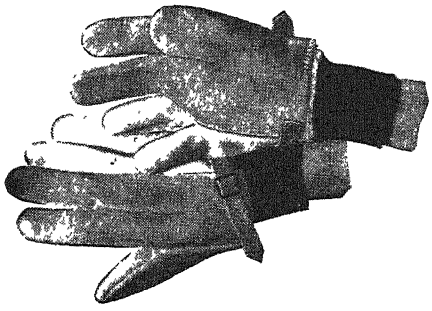
ABSORBING COMPOUND

A SIMPLE, economical, and labor-saving method of reclaiming oil or grease soaked shoes, clothing, belting, rope, and heat-treated parts is achieved by covering these articles with AleXite Absorbit Floor Compound. This multi-purpose compound, resembling uncountable numbers of tiny sponges, is fire-proof, vermin-proof, and sterile It absorbs many liquids from floors, including water, oil, grease, syrup, chemicals, inks, wax emulsions and paint ingredients It will absorb several times its weight in liquids

GLOVE GUARD

THE SERIOUS shortage of cotton and leather palmed gloves has been relieved to a considerable extent by the Industrial Gloves Company, who have designed the thumb and two finger guard illustrated

This guard is made of chrome leather and is large enough to fit over the regular cotton gloves. On most jobs the heaviest wear comes on the thumb and first two fingers so that the new guard not only makes for increased service from the new cotton glove when put on the job, but it makes possible the salvaging of many practically worn out gloves. As illustrated, this guard is inseam cotton thread sewed It may be had outseam steel stitched if desired



Protect where wear is heaviest

DRILL PRESS TURRET

AN ATTACHMENT for drill presses that is said to increase the capacity of any drill press four times, has recently been announced by the Chicago Drillet Corporation under the trade name Quadrill.

The new unit is a precision built rotary device that holds four tools. The desired tool can be placed in work position by a "flick" of the finger, thus eliminating the necessity of changing tools as in the single chuck drill press Only the drill in working position rotates while the other three remain stationary for safety purposes The entire unit is assembled to the quill and is driven from the spindle.

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Telescoptics

A Monthly Department for the Amateur Telescope Maker

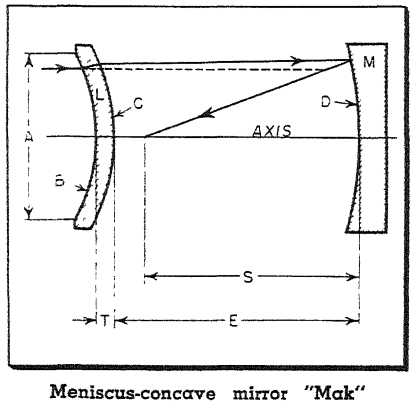
Conducted by ALBERT G. INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

SOMETHING new—destined many think, to become big in telescoptics—has suddenly burst forth like a nova the Maksutov telescope

First publication of design data concerning this intriguing invention appeared in the May number of the *Journal of the Optical Society of America* and at once this department began to hear from those of the more advanced amateurs who have access to that professional journal. They obviously were somewhat excited—plainly the Maksutov telescope "stirs up the animals." But, after all, why not? Thus far it looks stirring.

After a period for ingestion and digestion of this large, 15-page meal (just a bit hard going in spots for ordinary mortals) an invitation was extended to Norbert J. Schell, an engineer, 1019 Third Ave., Beaver Falls, Pa., widely known as the amateur who, with T. G. Beede, was responsible for the much-discussed off-side, or unobstructed reflector (this department April, 1939) and the off-axis and crisscross off-axis (May, 1940), to "put the Maksutov into such plain, simple terms that larger numbers of amateurs—the many who have made perhaps two or three mirrors but who are not yet optical design sharks—could take real hold of it." Schell was known to be in sympathy with the honest, direct presen-



Meniscus-concave mirror "Mak"

tation of technical subjects and of minimizing rather than inflating confusion for sweet confusion's sake. It has long been suspected, and one perpetrator has smilingly admitted the allegation, that a few whose brains function better than those of the rest of us in mathematics actually enjoy exploiting this advantage —keeping the suffering soul who isn't a genius as mystified and frustrated as possible; one adjunct to this kind of exhibitionism being the use of complicated, high-hat symbols and other slowing underbrush In his article Schell substitutes for a possible flock of $64 symbols plain old-fashioned *A, B, C, D,* and so on, and avoids other minor impediments to the unhappy The article by N J. Schell

THERE HAS just been released for publicity in this country the details of a new optical system invented in August, 1941, by D. D. Maksutov, of the State Optical Institute, Moscow, U.S.S.R. The inventor refers to it as 'Meniscus Catadioptric Systems" and describes its general application to telescope systems, although it is stated that the system is applicable also to other optical instruments. The release is given in a very friendly fashion, with special appeal and consideration for amateurs It appears to the writer that the design will prove of very great interest to amateurs, due to its advantages.

The system consists of combining the action of a single meniscus lens of rather deep curvature and of nearly constant thickness, with a concave spherical mirror, for the purpose of compensating the aberrations of the latter. The location of the lens in the fundamental design is in the path of light preceding the mirror, but the system also includes a modification permitting the lens to be located in the converging cone of light from the mirror near the focal point Only the fundamental design will be covered in this description. The drawing shows this design. [For Newtonian, add diagonal —*Ed.*]

By way of prelude, it should be understood that a spherical concave mirror reflecting parallel light from a distant point, such as a star, does not form a sharp image, since rays reflected from the outer parts of the mirror come to a focus closer to the mirror than those from more central parts This effect is known as "spherical aberration" (negative in this case) If we change the sphere to a paraboloid of revolution, this effect can be eliminated, but such a mirror still will produce distorted images of points other than those confined to a more or less restricted field of view surrounding the axis of the paraboloid. This effect is known as coma, and is usually not troublesome in the fairly narrow fields meeting requirements of visual observations in focal lengths *f*/8 and longer but is detrimental in the wider fields desired for visual observations and photography, in shorter focal-length instruments

The meniscus lens, on the other hand, can be designed so that it will have very little power as a lens, but with sufficient positive spherical aberration to compensate for the negative spherical aberration of the spherical mirror In addition, by suitably locating the meniscus, the coma is effectively eliminated for an adequate field

The meniscus thus pre-conditions the light ahead of the mirror—much the same as in the case of the correcting plate of the Schmidt camera, but with the difference that the surfaces of the meniscus are spherical and much easier to produce than those required for the Schmidt correcting plate

Also, the meniscus, acting as a very long focus negative lens, has very small chromatic aberrations (color), claimed by the inventor to be very much smaller than those of the usual doublet achromatic refractor objective; so that, even in short focal lengths, it gives images practically free from color on this account

The important advantages claimed for the system, as compared with refractors and reflectors, are as follows

1—Images freer from color, also much shorter focal lengths than refractors,

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as well as a wide choice of glass for the lens, permitting photographs in ultraviolet light

2—Closed tube construction, as compared with reflectors, thus reducing the effect of tube currents and abrupt temperature changes, giving much better protection to mirror coatings and, if desired, eliminating secondary supports by means of auxiliary mirrors fastened directly to the meniscus

3—More exact and uniform correction due to the facility afforded by the deep spherical surfaces of the meniscus: particularly as compared with reflectors of short focal length, other aplanatic systems, and off-axis arrangements

The elements of the system may be computed by the usual methods, of course taking into account the characteristics of the glass from which the lens is to be made. A complete mathematical treatment will not be attempted here but, instead, we may take the dimensions from certain empirical formulas which the inventor has supplied, to indicate a typical design. These dimensions are sufficient for practical purposes if for a chosen aperture the theoretically greatest ratio of aperture to focal length is not approached too closely, thus allowing for usual variations in different melts of the type of glass indicated. These dimensions apply to optical glass for the meniscus having a refractive index n_D 1.5163 and medium dispersion V 64.1, and with the stipulation that the meniscus thickness at center is 1/10 of its active theoretical aperture

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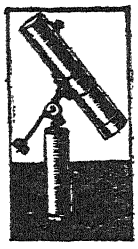

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In the drawing the following may be identified

L—meniscus lens
M—spherical mirror
A—aperture of meniscus
B—radius front surface of meniscus
C—radius rear surface of meniscus.
D—radius of mirror
E—distance mirror to lens at center
S—distance of focal plane from mirror at center.
T—thickness of meniscus at center

The figures in the table give factors, which, in each case, when multiplied by the chosen aperture in inches, give the dimensions applicable for a given ratio of aperture to focal length (*A/F*) These are tabulated from *A/F* of 1 3 to 1 5, also 1 8. The table also gives the maximum theoretical apertures for visual use in which all aberrations are within the Rayleigh limit, according to the inventor. For photography, these limits can be greatly extended, also *A/F* ratios greatly increased

Taking as an example, a design of 8" aperture and 32" focal length—that is, an aperture-focal ratio of 1 4—we find the dimensions as follows:

$A = 8"$
$B = 12.224"$
$C = 12.688"$
$D = 65\,856"$
$E = 43\,128"$
$T = 800"$ (1/10 of A, as stipulated)

In this case S will be approximately 33 6", as this figure is not included in the empirical formula and must be calculated

From the above example we find that the depth of the concave surface of the meniscus is .673", which, added to T, gives 1.473", the minimum thickness of glass required for the lens before shaping. In actual practice this should be upward of 1½", to allow for working, edging, and so on. As a comparison, the following are dimensions for two of the more familiar f/8 (1 8) Newtonian designs, usually favored by amateurs

$A =$	6"	8"
$B =$	14.486"	19 314"
$C =$	14.825"	19.767"
$D =$	97 620"	130.160"
$E =$	71.28"	95.04"
$T =$	.600"	.800"

The light diverges within and after leaving the lens, so that the active aperture of the mirror is slightly larger than the lens. The diameter of the mirror should be such as to take this into account, plus an allowance for full illumination of the field of view desired in any particular case. A trace of a ray (exaggerated) near the periphery is shown in the drawing, also a dotted line indicating the path it would follow if the lens were not used The point of intersection of this dotted line with the ray reflected from the mirror determines the focal length, and explains the difference between dimension S and the focal length. Note also that, since all three surfaces are concave to incident light in this fundamental design, the radii would be indicated as minus (negative) in design calculations.

To avoid possible misunderstanding, it is emphasized that the above table and examples apply only to the particular conditions specified, and that almost any desired modification in design can be made—for which, of course, the elements must be specially calculated by trigonometrical methods Regarding the glass for the lens, whether for the given example or not, the refractive index is more important than the dispersion, as it is the former which governs the accuracy of the correction for spherical aberration and coma The dispersion is not critical; it being desirable only to keep it as low as possible (greater V value)—preferably a type of crown, as indicated, for visual purposes—thus ensuring the most color-free images The mirror, of course, may be made of any kind of glass desired

The system can be extended beyond the limits imposed by spherical surfaces, even though these seem adequate, by slightly altering or retouching the surfaces

While this short description covers only the fundamental principle involved in image formation, it is obvious that practically any of the familiar arrangements of reflecting telescopes can be used in connection with it, and the inventor has in fact given most of these as examples, along with several innovations, not the least of which, in the writer's opinion, is an off-axis application in which all surfaces are spherical There is also a suggested method of reducing the size of the central obstruction in Newtonian types

Perhaps the feature having greatest appeal for amateurs is that of closed-tube construction, which should give much steadier images than reflectors, and at the same time provide an instrument practically as permanent and foolproof as the usual refractor, with the advantage of much shorter length

It is anticipated that an extended discussion of this interesting improvement will be forthcoming, in which the various arrangements and technical details will be fully developed. In the meantime, it seems that it would be appropriate if we referred to this design as the "Maksutov Telescope"

END of Schell's contribution

The name Maksutov is pronounced Mack-soo-tof, stress on the soo.

As Schell hints, other articles on the Maksutov will be forthcoming, short of the unforeseen

KNOWING of the recent tight situation on optical glass, and to get things started, your scribe scurried around and dug up promise of some 7 9" x 15_8" disks and then advised a few advanced amateurs Ten ordered the disks, and in this "Mak Club" are: Schell; Broadhead and Paul of western New York State; and the following members of the Long Island Astronomical Society: King, Cristman, Luechinger, Franklin, Cameron, Thorne, Rekouski. After a few months their findings should become available for the benefit of a later wave of aspirants, and by then it is hoped that the glass situation will not be so tight as it is at present.

However, this new Maksutov thing isn't going to run away, and a slow, level-headed evolution may prove more desirable than a big sudden blaze that cannot long endure.

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COVER: In the production of chlorine, highly important in the war effort, and equally important in the peace-time production to come, as told in the article starting on page 202, a salt solution is decomposed in electrolytic cells to yield chlorine and caustic soda. In the plant of the Niagara Alkali Company, where this process is carried out on a large scale, the resulting caustic soda is concentrated in a battery of evaporators, part of which is shown on our front cover, and used for other purposes.

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Previews of the Industrial Horizon

By A. P. Peck

NO FEAR OF SYNTHETICS

TIME was when people shied away from anything bearing the tag "synthetic." In many ways they coupled it with "ersatz" and considered synthetics in the light of substitutes that they had to accept for the time being. But the chemical industry has upset all that. People like the shiny, smooth, warm-feeling plastics that they know to be synthetics; women want synthetic nylon hose far more than they ever yearned for silk; lives are being saved by the thousands through the use of synthetic drugs.

The chemical industry has proved that by manipulating molecules and atoms it can produce materials which, in many ways, surpass anything that nature ever made possible Now it is learning something else. It is becoming more and more conscious that profits are to be found in greater bulk when basic chemicals are turned into new synthetic consumer products or into materials from which these products can be fabricated, than when these same chemicals are sold in carload lots to processors who reap the harvest. This new-type thinking on the part of the large chemical producers—Dow, Monsanto, Du Pont, Union Carbide, and others—is setting a new trend in the largest basic industry of the United States.

HIGH-TEST GAS

WHEN thinking of the millions of gallons of 100-octane gasoline being produced for our armed forces today, don't fall into the error of supposing that this same gasoline, when available for civilian use, will make high-powered superdupers out of old jalopies. Quite the contrary. If you put 100-octane fuel in the tank of a car that has an engine designed for 75-octane gasoline, the results will be disappointing. They may even be poorer than when using the type of fuel for which the engine was designed.

Gasoline rated at 100 octane must be squeezed harder before ignition to get the most out of it than is the case with lower-octane fuel. High-octane gasolines call for high-compression motors. Thus, with the know-how garnered through aircraft engine design, the automobile engine designers will be in a position to dream up engines which will out-perform anything ever mounted on four wheels in the past—*when* the high-octane fuel is widely available. Until that time comes, motor-car engines are going to be no better than the best pre-war.

Here is a case where the egg comes before the hen. The super fuel is here, will be available post-war. But remember that there are millions of cars on the road which cannot make efficient use of it, that it cannot be profitably and widely distributed until there are enough cars on the road that need it, and that it is of no benefit to present-day engines. It all seems like a vicious circle, but it is one that will be straightened out with time—not overnight

A CHANCE FOR THE LITTLE FELLOW

AFTER years of production for war comes the beginning of civilian production. Conversion has already started in a minor way. But when the war at last is over, then will start a race—a real race in which the devil of failure will surely take the hindmost—to meet the pent-up demands of civilian needs. Here as never before will be the golden opportunity for the little fellow, the independent, the smaller manufacturers who, pre-war, had to be content with crumbs. For an appreciable time after peace, it is probable that consumer needs will be far too great to be filled by even the big boys working at top speed. What will be more natural than for war-starved consumers to turn to less well-known producers rather than to wait their turn for the products of the big manufacturers?

Thus will come a revised version of the better mouse-trap. The small producers who turn out reliable products at reasonable cost will be in an enviable competitive position. They will be able, with wise management and adequate advertising, to ride a wave that, if they take full advantage of their opportunities, may soon put them in the class of the big boys. Failing that, they will not be too badly off in the role of medium-sized producers who, in a relatively short time, will have carved for themselves a reputation and a following that will insure at least moderate success

FLAME-SPRAYED PLASTIC

INTERESTING and significant is the recent announcement of the development by Du Pont of a flame-spraying method of applying polythene plastic to provide a high degree of protection against brines, chemicals, and other corrosive agents. Films of plastics thus produced are tough, uniform, and highly impermeable. They may be produced on metal, wood, glass, other plastics, and even on paper.

In the process, particles of the finely ground polythene plastic are passed through a flame where they are melted or softened These particles are then projected forcibly on the surface to be coated, where successive particles impinge on those previously deposited before they solidify. The coating is thus made continuous and free from even microscopic holes.

The physical advantages of flame-spraying, proved in the metallizing field, have now been extended to at least one plastic, with trend possibilities that reach beyond the presently visible horizon.

ABUNDANT CHLORINE

AN IDEA of the changing demand for chlorine (see also page 202) can be had when it is known that pulp treatment, the biggest pre-war user, averages about 200,000 tons annually, while the chlorine industry now estimates that needs of the chlorinated hydrocarbon family will run as high as 250,000 tons a year. One degreasing agent alone used 100,000 tons of chlorine last year.

FOR FUTURE REFERENCE

PRACTICAL electrical heating systems for homes may be based on reverse cycle refrigeration, in which the heat of the outside air, even in winter weather, is "condensed" to warm the interior of the house. . The quick-frozen food industry reports an increase of 15 percent in poundage during 1944 over 1943, with even brighter prospects for the future. . . Similar advances in dehydrated foods may make an interesting battle between the two methods. . . Success of NE (National Emergency) steels has shown that, contrary to former opinion, many low-alloy steels will give satisfactory service and that steels should be selected by physical properties rather than chemical composition. . . It is predicted that the real post-war car (when it arrives) will use 15 to 20 pounds of plastics, as against five pounds pre-war.. . . And this is without considering the "plastics car" of the dreamers. . . Those having an interest in the liquor industry (whether from a thirst or a financial angle) should keep an eye on the Anti-Saloon League, which is reported to have set $5,000,000 as their goal for a prohibition war-chest and to have already accumulated over $3,000,000. . . Infra-red lamps loom as a possible replacement for winter blankets on your bed.

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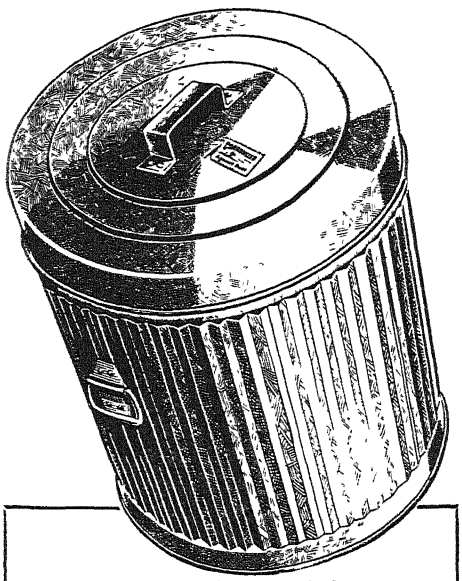

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Corronizing is an amazing new armor against rust that makes metals last up to 4 times as long. The Corronizing process has been developed thru years of research by Standard Steel Spring Company—and has been proved on vital war equipment on every fighting front.

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The Corronizing process is already available to all makers of metal products. Soon, on more and more metal products, you'll find the "Corronized" label identifying 4-times-greater values. Look for it—ask for it. It's your assurance of products that will defy the ravage of rust up to 4 times as long.

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SCIENTIFIC AMERICAN

(Condensed from Issues of November, 1894)

CANAL — "The company which has just been formed for taking over the works at the Isthmus of Panama has issued a report, giving what it professes to be an accurate idea of the present state of the canal . . So far, no plan for completing the canal has been definitely adopted, and this matter will be left to the technical commission which will be appointed as soon as the company is in working order."

BALLOONING — "An interesting experiment in aeronautics was tried in the latter part of September to determine the conditions under which a series of ascensions might be made for a certain number of days, executed successively with the same gas and the same balloon. . The trip continued for a week. The ascensions were determined by the action of the sun's rays, which expanded the gas and dried the material of which the balloon was made. The descent invariably took place by reason of condensation at twilight. During the entire trip it was not necessary to open the escape pipe."

RUSSIAN RAILROAD — "A length of 2200 miles of the Russian Pacific Railway is now open and Omsk is now reached by rail. The cost has been about $44,000 per mile. The natural conditions were on the whole unfavorable. . . On the sections between Ufr and the Sima River there was, between Urakowo and Bulaschawa, a bog of about 60 miles extent, which had been formed through the rain water accumulating in the course of thousands of years in this natural pit of granite"

GREAT AND SMALL — "Modern science has . . . revealed the beautiful processes of nature, but it has also revealed her destroying agencies. The more closely man has studied, the more complicated has he found conditions and the more dangers has he recognized. Where all is outwardly lovely. he has found inward harm. The microscope has disclosed minute horrors, none the less horrible because minute. The telescope, as it sweeps the heavens with its farseeing eye, has foretold stupendous catastrophes. Much that was thought beneficial has been proved dangerous, and much that was thought harmless has been proved fatal."

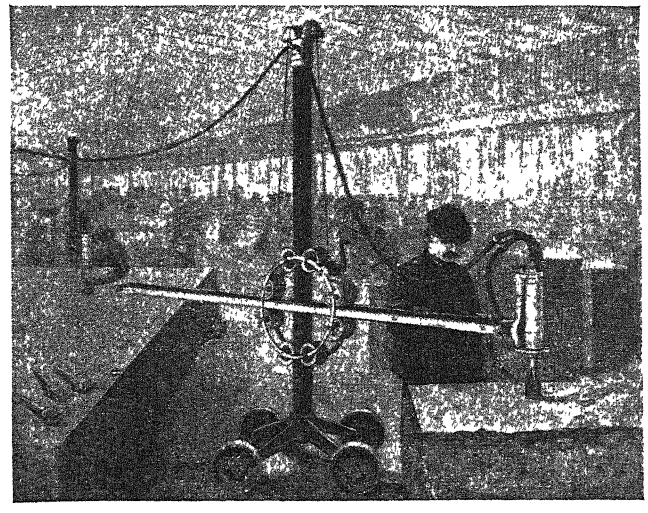
HOBBIES — "The man who undertakes to cultivate some fad like the growing of plants, the raising of fish, photography, entomology, boating, bicycle riding, athletic sports, microscopy, painting, drawing, music, fishing, hunting, and a thousand and one other things which may come under the head of personal recreation has always something within his reach which makes him independent of the outside world. . . All harmless amusements, but more valuable than gold, because they take a man away from himself."

JAPS FOLLOW — "An officer of the Japanese navy has written a letter to a friend in this country, in which he speaks highly of the efficiency of several American electric search lights used in the fleet to which he is attached. These lights stood the test of actual service better than the English and German apparatus, which will be doubtless condemned by a board of survey. He also states that the best maps of the Yellow Sea and Corea are from the United States Hydrographic Office in Washington."

COLD STORAGE — "Money can be borrowed on butter, eggs, cheese, chickens and farm produce of all kinds that will keep, as easily as on diamonds and watches. . . Cold storage and the development of the storage warehouse business in New York have made this possible. . . The banks will accept storage certificates for collateral as readily as they would United States bonds, when the application for a loan comes to them through men whom they know."

WORK AND WORRY — "It is a well understood fact that it is not work that kills, says the Massachusetts Medical Journal, but worry, and from this text some most sensible and profitable hygienic discourses have been preached during recent years."

STONE DRESSING — "We illustrate one of the improvements introduced by the American Pneumatic Tool Company . . . the new portable stone dressing machine. This machine is designed for use on the hardest granite for working it to a surface. . . The stone to be operated on is placed in about the position required to work it by hand; the stone dressing



machine is moved to any convenient place near the stone (or the stone to the machine), the play of the counterpoise is adjusted for the height of the surface to be operated on, and the tool started. The hard granite at once succumbs, and in a very short space of time the surface begins to take shape. . . The exhaust of the tool is caused to maintain a blast against the point of the tool to blow away the chips and dust. In the foreground of the picture the machine is shown operating a cross chisel, while fine brushing is shown in progress in the background, the operator holding the tool in his hands so as to regulate its work."

NOISE — "The great increase in mechanical appliances and the growth of populaton in cities has brought about a disagreeable effect, the increase of noise. From the private office, where the rattle of the typewriter has proved the successor to the classic squeaking of the quill pen, to the street, where the traffic of carriages and carts is overtopped by the roar of the elevated railroad, our life is spent in the midst of noise. It would seem that not one field but a hundred or more fields are open to the inventor who will attack the noise problem in its minor as well as major phases. When a machine, in addition to doing its work, produces noise, the latter is pretty certain to be the indication of a useless expenditure of energy if not directly the cause of such waste."

LUMINESCENT LAMP — "The luminous substance of Ebert's 'luminescent' lamp is said to be a small disk of compressed luminous paint. This is enclosed in an exhausted glass receiver upon the external surface of which are glued two strips of tinfoil, to which the terminals of the circuit are attached. When the electric oscillations act upon these coatings, active cathode rays are formed on the inner surface. These, though almost invisible themselves, produce a strong luminescent light upon the surface of the luminous paint."

HOT AND COLD — "On one occasion, when M. Pictet was suffering from a severe burn due to a drop of liquid air, he accidentally scorched the same hand very seriously. The scorched portion was healed in ten or twelve days, but the wound produced by the cold burn was open for upward of six months."

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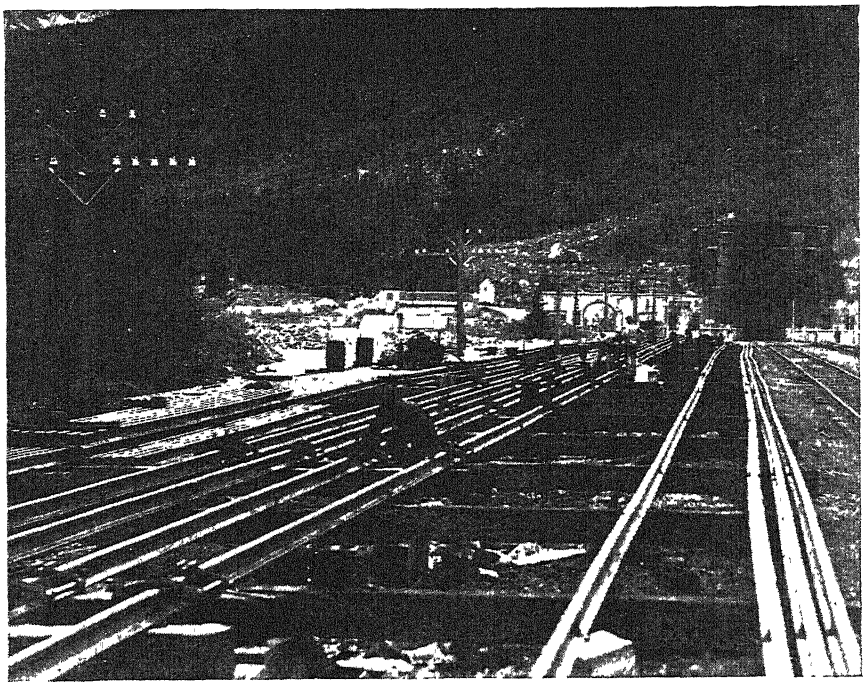
METALS IN INDUSTRY

Conducted by FRED P. PETERS



Thermit welding of railroad rails outside the Moffat Tunnel, Colorado

Thermit Branches Out

Intense Heat (Above 4500 degrees, Fahrenheit) is Generated by Reaction of Granular Metals When Correctly Ignited. The Heat Alone Can be Applied to Many Uses, or the Resulting Metallic Mass Can be Used for Construction or Repair Purposes. Major Trends are Now in View

By KENNETH ROSE

Engineering Editor, *Metals and Alloys*

An ore bridge has been prepared for demolition by The Interlaken Iron Corporation: whistles warn the workmen to move to places of safety. Wires run to packs around four of the eight steel columns supporting the towering structure The engineer in charge assures himself that everyone is out of danger, then nods to the assistant at his side. A plunger is pushed—but there is no answering roar of explosives. Has something gone wrong? Not at all, for within a few seconds the steel tower starts to totter, then tilts, slowly at first, and crashes to the ground in the predetermined spot.

The agent that has so silently toppled this structure is thermit. A stable, granular material, non-explosive and perfectly safe to handle, it is capable of producing a molten metallic mass at a temperature above 4500 degrees, Fahrenheit, when properly ignited. Heat from this molten metal fused the steel columns in the ore bridge at the areas where it was placed, causing the bridge to collapse.

Thermit, just at present, brings up thoughts of incendiary bombs, and it was widely used in at least one type of aerial missile. The extremely high temperature generated by thermit makes it suitable for such use, although other preparations have now been found that are more suitable from a military standpoint. The thermit mixture is so stable that a temperature of 2400 degrees, Fahrenheit, must be produced by an ignition powder to start the reaction. This ignition powder is composed of a mixture of materials which can readily be ignited by a simple means and which will then quickly reach the temperature necessary to start the thermit reaction. Some ignition powders can be started by the heat of a match, an electric spark is frequently used.

Chemically the thermit reaction is quite simple. Aluminum and a metallic oxide react to form aluminum oxide and the original metal, intense heat being generated during the reaction. While most familiar in connection with the oxide of iron, the same reaction will liberate chromium, nickel, manganese, titanium, vanadium, molybdenum, silicon, tungsten, columbium, boron, and other elements from their oxides Its discoverer, Dr Hans Goldschmidt, of Essen, Germany, obtained his first patent in connection with the use of the process for the reduction of chromium and manganese. It is still used commercially for the preparation of these two metals, and of ferro-titanium also.

A few years after its discovery the process was applied to welding by the Goldschmidt Thermit Company. The steel, produced at the very high temperature of the reaction, theoretically about 5000 degrees, Fahrenheit, was poured into a mold surrounding the parts to be welded, and the whole was fused into a single unit. It was as a welding process that the thermit reaction came into widespread recognition and use. The original company eventually was acquired by Metal and Thermit Corporation.

Because of its simplicity in method

and required equipment, the process was used is the early nineteen-hundreds for welding street railway rails The welding could be done while the rail was in position Welded railway rails were more generally used in Europe than in this country, but many of the larger American cities used the method for repairs, or at places where service conditions made it advisable to eliminate joints between rails.

Railroads began the use of thermit-welded rails more than ten years ago Maintenance of track inside tunnels is difficult, so that welding of rails into continuous lengths was especially advantageous in such locations. It is the usual practice to weld the rails outside the tunnel, and to drag the continuous length into place. Considerable interest was shown in the installation of welded rails in the Moffat Tunnel, near Denver, Colorado, more than a year ago In this six-and-a-quarter-mile bore the rails were joined into 1000-foot sections outside the tunnel, dragged into place, and closure welds were made inside the tunnel to join the sections into continuous lengths.

Rail welded into continuous lengths in the open is exposed to greater variations of temperature, since the actual temperature of the metal exposed to the sun's rays may rise substantially above that of the atmosphere. This poses the problem of expansion and contraction The normal expansion of rail under a 100-degree rise in temperature is about 41 inches per mile Temperature conditions have been reported under which expansion might exceed 60 inches

However, experience has shown that no difficulty will result if the rail is placed while the air temperature is about 60 degrees, Fahrenheit, halving the maximum range of temperature and the resulting stress, and if the rail is properly restrained. Any tendency on the part of the rail to move is prevented by anti-creepers, spring clip fastenings, and similar holders.

HEAVY EQUIPMENT REPAIRED—Repair of heavy equipment has formed the bulk of thermit welding applications for many years. Recently a broken shaft on a large Mississippi River paddlewheel steamer was welded without removing the part from the boat. Frames of heavy machinery have been repaired by this process Both cast iron and steel can be welded, although the former metal requires caution, due to the difference in thermal expansion between it and the weld metal

In steel mills, worn equipment has been built up by fusing thermit steel to the abraded surfaces. Repairs have been made to rolls, crankshafts, pinions, and other parts by this method of casting hot steel around worn or broken parts.

More recently heavy parts have been fabricated by joining several castings or forgings with thermit welds Heavy crankshafts are made from two forged shaftings, a pin, and two forged blocks. The method of fabricating this heavy piece of equipment is typical of that in general use. The parts are lined up and the proper size gaps are cut with an oxyacetylene torch. Then wax is filled into the gap in the space to be occupied by weld metal, a sheet metal mold box is placed about the area to be welded, and a special refractory mixture is rammed up around the wax pattern and the parts to be joined After the wax is melted out and the parts preheated, thermit powder in a special crucible is ignited, then tapped into the mold a few seconds later, and, after cooling, the weld is completed. Gates and risers may be trimmed off with a cutting torch

Stern frames for the huge shipbuilding program were taxing steel foundry capacity for castings of this size These frames were roughly 20 to 26 feet in outside dimensions, and of irregular outline. It was decided to cast the frames in sections, and to join these smaller castings by thermit welds Liberty ship stern frames were cast in two sections, requiring one weld, while the larger Victory ship stern frames were made in four sections, requiring four welds. So satisfactory did this method prove that it has been adopted in almost all of the shipyards in the country.

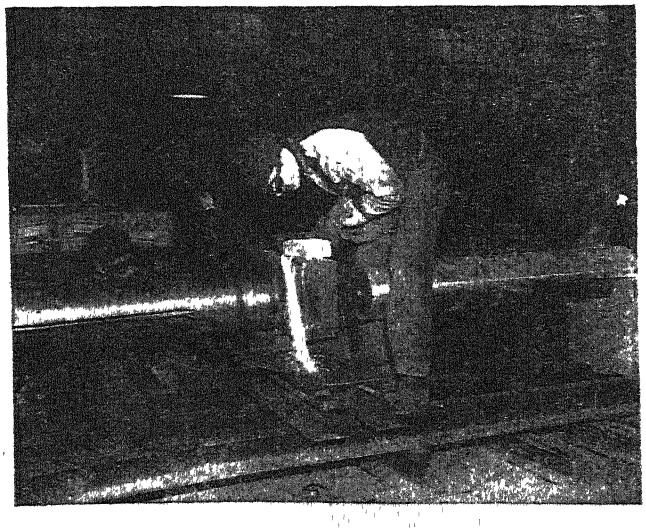
Thermit powder, as ordinarily employed, is composed of 23 25 percent fine granular aluminum and 76.75 percent processed mill scale The processing is a roasting operation to increase the percentage of oxygen in the mill scale, and hence increase the yield of molten metal from the reaction By this roasting, the equivalent FeO of the mill scale is lowered from 56 percent to about 18 percent. The subsequent reaction will produce about half as much steel as the original weight of thermit powder.

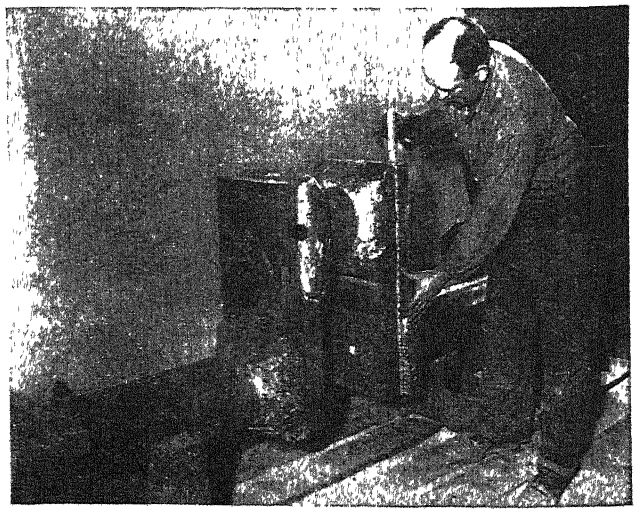
Lower Left: The ends of a crankshaft to be fabricated by thermit welding are flame-cut. Above: Molten thermit steel is tapped into a flask surrounding the parts to be joined. Lower Right: The finished crankshaft, plainly showing the welded areas

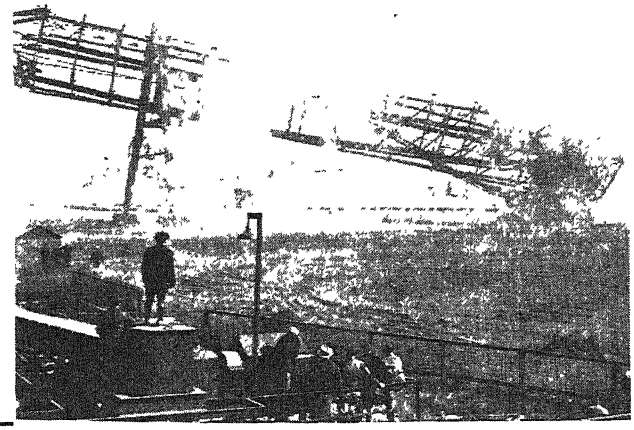
STEEL IS ADDED—In order to increase further the quantity of steel obtained from the reaction, about 15 percent of steel punchings is usually added to the mixture. The great heat generated by the thermit is sufficient to melt this additional steel—indeed, the added metal may be increased as high as 50 percent without lowering the temperature below about 3300 to 3400 degrees, Fahrenheit. However, in order to assure a complete fusion with the work, it is usually desirable to add only enough metal to maintain a temperature of about 4000 degrees, Fahrenheit.

A wide range of composition of thermit weld metal is available. The reaction, as already stated, can be used with a number of metallic oxides. By using a mixture of oxides in the thermit powder, or by adding pieces of another metal or alloy, carbon content and content of alloying elements can be controlled.

Steel, when cast in the foundry from a high temperature, tends to hold dissolved gases, and must be deoxidized







Demolition of an ore bridge was recently accomplished by the aid of thermit, which was employed to melt the supporting columns, as described in text

by some means In the case of thermit, an excess of aluminum, one of the deoxidizing agents used in steel manufacture, insures against "wildness" in the poured metal. Thermit steel is quite dense, since it solidifies from the inside out because of the presence of the parts to be welded. These metal parts, being at a temperature much below that of the weld metal, take heat from it, and cause the weld metal to chill first approximately along the axis of the work

An interesting use of the thermit process is to prepare metal for small castings, usually for emergency repairs, when no melting equipment is available This sometimes happens in isolated mining districts, as in Australia and South Africa. The correct thermit powder must be obtained, or the necessary composition made up by adding pieces of the desired constituents The reaction is started in the usual thermit crucible, and the metal is run into sand or other molds, as in ordinary foundry practice.

The thermit process, originally used in heavy engineering chiefly for repair and maintenance work, has added in recent years a respectable list of "new construction" applications, of which the joining of forgings or castings (like the ship stern frames mentioned earlier) is typical. This trend is expected to continue into the post-war period, with thermit welding emerging as a major method of engineering construction

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ALUMINUM-BRONZE EXTRUSIONS

Have Desirable Properties for Many Uses

A VERY recent and significant development in the field of metal-forms has been the availability of extrusions made of the mechanically desirable but hard-to-work aluminum-bronze alloys. Long known for their hardness, tensile strength, and corrosion resistance, these alloys have generally been available chiefly in cast rather than wrought iron.

Extrusion equipment developed for and employed at the Wrought Products Division of Ampco Metal, Inc., is built around a hydraulic horizontal type Schloemann press having a capacity of 2275 tons total pressure on the main ram and equipped for tube extrusion with piercer attachment of 275 tons

The extrusion process has so increased the physical properties of the already strong aluminum bronzes (especially those containing 2.5 to 5 percent iron and 8 5 to 15 percent aluminum) that they are finding increased use for aircraft engine parts, landing gear parts, propeller parts, bearings, and so on.

SKIN RECOVERY

Corrects Deficiency in Heat-Treated Steel Surfaces

DECARBURIZATION of steel—the lowering of the carbon content at the surface and hence the formation of a soft skin —has probably brought more headaches to heat treaters, metallurgists, and steel manufacturers than any other problem associated with heat treating

A new method of surface treatment developed by Surface Combustion Division of General Properties, Inc, comprises restoring carbon to the depleted surface by heating the steel in a gas atmosphere under conditions so controlled that carbon enters the steel surface in exactly the right amount to correct the deficiency

In typical cases carbon recovery is complete and within 0.03 percent of the original carbon in the steel. For example, forgings receiving the treatment have shown no signs of failure due to surface conditions, in sharp contrast to the high mortality rate observed before the use of the skin-recovery process.

OUTSTANDING DEVELOPMENTS

Listed in the Metal-Engineering Fields

BASED primarily on a survey by Edwin F. Cone of the opinions of leading engineers and metallurgists in the metal-working industries, *Metals and Alloys* has just issued a list of the ten outstanding non-secret wartime developments involving new materials or metal-processing methods that have made major contributions to Victory and which have considerable significance from the standpoint of post-war materials and processes.

The ten leading developments all fall within the framework of three broad achievements for which American metal-working plants, the War Production Board, and Army Ordnance share top honors These general programs were

a. Expansion in metal-production, especially of steel (about 10 million-ton increase) and of light metals.
b. The conservation program—including substitution, process-conversion, and salvage—that stretched our available metal supplies phenomenally.
c. The co-operative pooling of know-how on materials and methods by all industry

Specifically, the 10 chief materials and methods developments (listed here not necessarily in the order of their importance) were found to be·

1. The development and use of the National Emergency (NE) alloy steels
2 The development of special heat-resistant steels and alloys and of precision manufacturing methods for turbo-supercharger and gas-turbine components
3. The development of new high-strength aluminum alloys and of clad aluminum alloy combinations far superior to the best available before the war.
4 The production of magnesium from seawater at plants on the Texas Gulf Coast.
5 The expansion in the use of welding for fabrication, especially of ships
6. The application of tungsten carbide tools (especially for high-speed milling) to increase the output of machining operations.
7. The development and performance of heat-treated cast steel armor plate.
8 The rapid development and wide use of new methods of "packaging" steel products to protect them against corrosion, particularly during overseas shipment.
9. New resin-bonding adhesives for joining metals to metals and to non-metals, sometimes with the strength of welds.
10 The production of forged aluminum cylinder heads for airplane engines, permitting considerable increases in power per unit of engine weight

BRIGHT ELECTROPLATE

Has Nearly the Reflectivity of Silver

A NEW bright alloy electroplate has recently been placed on the market by Hanson-Van Winkle-Munning Company, that has a combination of properties not heretofore available in electro-deposited coatings.

The deposit, an alloy of copper, tin, and zinc, is bright as-plated, is non-magnetic, and has a reflectivity nearly that of silver. It is tarnish-resistant and efficiently protects the underlying metal (usually copper or brass) from corrosion.

The coating is abrasion-resistant and can be bent and formed without peeling if thinner than 0 0002 inch.

Abundant Chlorine

Production Capacity for this Common but Important Chemical is Now Double that of Pre-War Times. This New Abundance Will Make Chlorine Available for the Development of New Derivatives and Applications and for the Expansion of Old Uses that Have Already been Proved in Practice

AFTER Victory, many things will be different. Novelties and wonders will grow out of this war's developments to make the post-war world a far better place to live. But the novelties we hear most about will be far less significant than homelier developments of familiar things expanded to greater usefulness. Plastics, light metals, and 100-plus octane gasoline fill principal roles of miracle workers in imaginative accounts of tomorrow, for, we are soberly told, they will give us pre-fabricated houses, jitney airplanes, and automobiles that will run countless miles on each gallon of motor fuel. Perhaps that is so. These and other strange novelties will undoubtedly be interesting, but the really vital aspects of tomorrow are bound up with more familiar things made newly abundant through production facilities swollen huge for war. Chemically, this is particularly true, for chemistry and the chemical industry work with the intrinsic natures of materials and little, if at all, with those superficial aspects which most inflame the imaginations

Chlorine illustrates this new abundance and its consequent effects on usefulness. Certainly it is familiar and many of its applications and derivatives are well and long known. Some derivatives of chlorine will receive such attention as to make them appear quite new; but by and large the developments that are really vital to tomorrow have already been under way for a long time.

The new phase is one of quantity and hence price. In 1939, our capacity to produce chlorine in commercial plants was 1700 tons a day. That compares with 617 tons a day in 1925 and with nearly 4000 tons a day in 1944. This excludes capacity owned and operated solely by the government, which may or may not be available for commercial production at war's end. Clearly such an increase in production, when no longer needed for war, will affect our future. Great pressure to sell over-production may be expected to encourage new and to enlarge old outlets for this product at the end of unnatural demand.

Courtesy Niagara Alkali Company
Electrolytic cells in which brine is decomposed to yield chlorine and caustic soda

The implications of enlarged markets for any staple commodity extend in all directions and into many fields. Obviously, changes of price and quantity affect both direct producers and consumers at once.

Sometimes these effects are spectacular; more often they attract little attention. Yet their importance can scarcely be over-stated. Without the goad of war, with its demand that could not be denied, reductions in the costs of many products take years instead of months. Liquid chlorine, for example, sold for 27 cents a pound in the early days of its production in this country (1907) and it required three decades for it to come down to 1.75 cents a pound

REFLECTED COST DROPS—Costs of chlorine derivatives seldom drop in proportion to that of the gas itself. Indeed, since numerous other raw materials enter these derivatives and one or more processing steps are required for their production, it would be surprising if any exact correspondence did exist. Yet the fact of cheaper and more plentiful chlorine is sure to be reflected in ultimate lowered costs of its products and in their greater abundance; and these factors quite naturally will encourage tomorrow's development of new and enlargement of old markets.

Looking forward to peace, we can safely anticipate a potential output of chlorine substantially more than double the corresponding pre-war figure, even assuming that government-owned plants will not enter the general market. Without going beyond 1939's uses of chlorine and those brought to special prominence in the war period, its early post-war future can be readily approximated. Obviously, invention must be barred from the discussion lest we be carried away by our own dreams and lose ourselves and any possible value of this discussion by the same fault that nullifies the value of most forecasting of the post-war future.

Outstanding consumer of chlorine is its producer: the chemical industry itself. From the yellow-green gas come a host of valuable products formed through its chemical reactions with many different raw materials. Chlorine,

PRINCIPAL COMMERCIAL USES OF CHLORINE—PRE-WAR

Chemical Industry

Aluminum Chloride
Amyl Alcohol
Amyl Chlorides
Anilin Oil
Beryllium
Bromine Recovery
Carbon Tetrachloride
Chloramine T
Chlorinated Diphenyl
Chlorinated Naphthalene
Chlorinated Rubber
Chloroform
Chloropicrin
Cyanogen Chloride
Dichlorodifluoromethane
Dyestuffs Manufacture
Ethyl Chloride
Ethylene Chloride
Ethylene Glycol
Ferric Chloride
Hydrochloric Acid
Hypochlorites
Insecticides, Fumigants
Lead Oxide
Magnesium Metal
Metal Chlorides
Methylene Chloride
Monochlorobenzene
Orthodichlorbenzene
Paradichlorbenzene
Pentachlorethane
Petroleum Refining
Phenol, Synthetic
Phosgene
Steel, Pickling
Sulfur Chlorides
Tetraethyl Lead
Tin Crystals
Trichloroethylene
Tungsten, Metallurgy of
Vinyl Chlorides

Bleaching

Bleaching Shellac
Pulp Bleaching
Textile Bleaching

Sterilizing

Sanitation of Industrial Wastes, Sewage, and Water
Slimes, Condenser and Pulp Mill, Prevention of

Miscellaneous

Chlorination of Wool
Flour Maturing
Glucose
Respiratory Diseases, Treatment of

by this very chemical activity, is also an invaluable tool to enter and alter molecules and convert them to others having particular values Some of these products contain chlorine in their final state, but many are simply transformed when chlorine is introduced into its molecule and later removed. More than half our chlorine production is normally consumed in chemical operations.

Chlorine possesses extraordinary ability to bleach and whiten paper, wood pulp, and textiles, and this bleaching action is its second great use. Bleaching powder, made by combining chlorine with lime, was at one time the exclusive chemical bleaching agent but the greater economy and effectiveness of chlorine itself, as well as its freedom from some of the drawbacks of bleaching powder, have permitted it to replace the older agent practically completely.

The third great service of chlorine in point of quantity, and by all odds its most important one on every other basis, depends upon its strong germicidal properties. Tiny dosages of chlorine added to water supplies effectively destroy the bacteria of certain diseases formerly spread by drinking water. Most notable of these is typhoid fever, once a universal plague but now, thanks to chlorine, a rarity in the United States even with density of population always growing. Similar treatment of sewage overcomes or minimizes the contamination of streams from this source. Chlorination of industrial water for certain uses prevents troubles arising from the growth of certain slime-forming organisms in plant equipment.

One might well add to the list of applications of chlorine a fourth miscellaneous class having considerable utility but falling outside the foregoing important groups. Into this class fall the treatment of respiratory diseases by atmospheres containing safe but germicidal concentrations of the gas, maturing of flour, pickling of steel, and a few others of smaller significance.

Chlorine's value in post-war developments and the trend apparent from the expanded production of the war period may be deduced from consideration of a few of its outstanding applications. Clearly, reduced costs resulting from cheaper chlorine will be reflected in widened markets and these in turn will raise standards of living in a number of ways. The same thing is likely to happen in other parts of our economy quite aside from any effects which may be produced by entirely new inventions or new adaptations of older ones It therefore behooves us to take special account of recent important factors in our lives and to look into the probable effects on tomorrow of their considerable expansion.

USES OF COMPOUNDS—Four uses of chlorine compounds will suggest the probabilities in chemical industry's operations: Vinyl chlorides for resins; solvents for dry cleaning; refrigerants; and insecticides.

A number of different vinyl and vinylidene chlorides possess the ability to form synthetic resins. Two classes of resins containing chlorine possess important values. Vinyl chlorine resins can be made with a rubberlike character once familiar in belts, suspenders, tobacco pouches, and other such items. Curious as these novelties are, their importance is trivial beside the application of the same resins to the problem of protecting ships from magnetic mines Here the vinyl resin forms the insulation of the de-gaussing cable, major protective device. Advantages are high insulating value and resistance to moisture, sun, ozone, and weather, combined with a satisfactory degree of flexibility. This use suggests important post-war applications in various electrical fields where weather destroys rubber or nullifies its value rather too quickly. New efficiency and longer life of insulation on electric lines may be realized through this use of chlorine

The vinylidene chloride resins lack rubber's elasticity but are highly resistant to chemical attack. The ease of their fabrication has led to the development of highly resistant pipe and pipe fittings which can be readily and cheaply installed, and which possess great value in chemical plants and other locations subject to highly corrosive conditions. Another type of the same basic resin makes "wire" insect screen of high weather resistance and a rattan-like product having long life, resistance to washing and cleaning, and other advantages when used in caning chairs, seat backs in railroad cars, and like services.

DRY-CLEANING CHANGES—Fire-resistant, non-flammable solvents had before the war put dry cleaning into shops on the main streets of towns instead of remote locations previously required by fire laws. Retail establishments could quickly and efficiently clean garments practically while you waited. They could, that is, so long as chlorinated solvents were to be had. Just now dry cleaning has returned to its flammable solvents, its isolated locations, and its wholesale plants where proper precautions can be taken against fire. But this seems likely to be a temporary move and one to be reversed when war demands for chlorine abate and free it for making the kind of solvents required for retail shops to practice this art.

The Freon refrigerants, typified by dichlorodifluoromethane, now carry with them to war great quantities of chlorine consumed in their production. The air conditioning and refrigerating systems of ships, for example, are safe and efficient because their working fluids are these non-toxic, non-flammable refrigerants The same products also serve the important purpose of motivating the mosquito bombs which effectively spray insecticide into the air of an enclosed space to rid it of mosquitoes and other annoying and dangerous insects. These highly effective instruments play a leading role in the comfort and protection of our armed forces in insect infested places.

Chlorine also enters the composition of many important insecticides and performs an essential service in the synthesis of others. Typical of the first group are paradichlorobenzene, familiar in household moth-controlling preparations, also a later development which has come into extraordinary prominence for its remarkable ability to destroy body lice and thus protect our soldiers from typhus fever. The second group can be represented by ethylhexanediol, a valuable repellant for insects,

Courtesy Niagara Alkali Company

Evaporators for concentrating the caustic solution produced from brine during the manufacture of chlorine

The foregoing paragraphs merely suggest, and by no means exhaust, the chemical products into which chlorine enters. Each of them may be affected to some greater or lesser extent by the abundance of chlorine after the war. Just how great this effect may be on any one of them cannot now be determined. However, should each of them be made a little cheaper and a little more plentiful, the combined effect on comfort and the standard of living of many is sure to be immense.

One is no little comforted that practically all municipal water supplies in the United States and Canada—so nearly all of both publicly and privately owned supplies that the number missing is negligible—have the benefit of chlorine treatment to destroy any noxious germs they might otherwise carry The few exceptions draw naturally germ-free water from deep wells. A further fact is that public water supplies are made safe to drink at a cost of somewhat less than one cent per person per annum! Certainly that is cheap enough for a service so vital.

Large quantities of chlorine are now consumed similarly by our armed forces in sterilizing and purifying the water they must use. The technique of supplying this important service wherever it may be required represents a significant development Heretofore export of liquid chlorine has been hampered by the necessity for handling cylinders as deckload on ships to avoid hazard in case of leakage, and by the necessity of returning the heavy, expensive cylinders for refilling. Compounds containing active chlorine in a form suitable for water purification have usually been uneconomical as means to get supplies to remote points. However, development of methods of supplying our forces throughout the world and at the same time proof to native populations everywhere of the efficacy of the chlorine treatment of water, leave no doubt that this will be an important factor in chlorine's future.

That becomes spectacular in the light of the cold facts of typhoid fever, outstanding example of water-borne disease Before 1910, when water treatment was new, the death-rate in the United States from typhoid fever had been gradually reduced to some 25 persons annually per 100,000 of population The present death-rate from this disease is approximately one twentieth of this number.

Obviously, reduction of cost of chlorine will have at most a trivial effect on water treatment in this country However, cheapness combined with other vital factors is likely to encourage the adoption of effective sanitary measures in other countries which still suffer large numbers of deaths annually from this dread disease.

Without laboring the point, it seems clear that essential changes and improvements in our post-war world can and will come from the efforts producers must make to sell their swollen outputs after war's demand stops. The point could be as well illustrated by choosing another material than chlorine, or even a different list of its derivatives. Nevertheless, the conclusion is inescapable that we must and can with safety look to the cheapening of customary products and their consequent widening use both at home and abroad for the greater part of our post-war prosperity. It is all very well to hope that fantastic dreams will come true, but that hope is scarcely reliable.

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CARCASS STOCKS

Improved by Use of Litharge Activator

RESEARCH recently conducted at the laboratories of the National Lead Company definitely establishes the fact that litharge-activated GR-S compounds can be achieved with far superior aging properties, with desired curing rate, stable over an extremely wide curing range, and with improved heat build-up. This has been accomplished by using litharge as an activator for thiazole or thiuram accelerators with low sulfur content.

Many investigators did considerable research into accelerators for use in the compounding of GR-S stocks soon after the development of GR-S as a replacement for natural rubber. Chemists of the National Lead Company succeeded in producing activation by litharge, which has resulted in a satisfactory carcass stock for vehicle tires.

LAMINATED PLASTIC

Gives Added Protection To Military Airmen

A NEW three-ply laminated plastics sheeting has been designed to give added protection to American airmen flying in pressurized high-altitude planes. The new sheeting reduces the possibilities of disintegration of clear plastic canopies when pierced by bullets or flak while flying at high speeds under pressurized conditions.

Called laminated Lucite-Butacite, it consists of a single layer of Butacite polyvinyl butyral resin sandwiched between two layers of Lucite methyl methacrylate resin. Perfection of the sheeting was recently announced by E. I. du Pont de Nemours and Company.

Tests conducted by both the Army and the Navy show that, under certain conditions, the new laminate has a self-sealing tendency in that holes created by bullet penetration close up almost completely because of the rubber-like nature of the Butacite interlayer sheeting

At ordinary temperatures, even under pressure, the hole left by the bullet is small and the amount of shattering is not excessive. In most cases, the hole may be promptly sealed with a patch, permitting maintenance of essential air pressure within the cabin. Solid clear plastics usually shatter beyond repair when struck by a bullet in low temperature and under high pressure.

TEXTILE CHANGES

Wrought by Application Of Chemical Research

RADICAL developments in the chemical treatment of fibers, which will have a profound effect on the post-war textile industry, are announced by Monsanto Chemical Company.

As a result of research dealing with chemical treatment of natural fibers, the company claims that its accomplishments to date include:

Treatment of wool so that it won't shrink.

Treatment of both cotton and wool so that the wearing qualities of these fabrics will be doubled.

Treatment of serges to eliminate the shine from the cloth.

Treatment of wool so that it creases durably under steam and heat. Thus trousers or suits that are pressed will retain the crease even in a rain and will not wrinkle when packed into a suitcase.

Treatment of fibers so they will not slip. This means that stockings will not run nor will seams pull out.

All of these developments, it was announced, are based on new techniques of treating either the surface or the heart of fibers to produce the desired effect without in any way changing the feel or texture of the material. In some cases the treatment involves the deposit of a submicroscopic film of plastics. In the case of the elimination of runs in stockings, the treatment involves the deposit of silica or submicroscopic grains of sand. This prevents the fibers from slipping out of the positions into which they were knitted, yet does not alter the feel or texture of the fabric.

Part of a long-range research program into the chemical treatment of textiles, the results up to now include greatly increased water-repellent qualities for cottons and rayons and increased fastness to washing or dry cleaning through impregnation with chemicals which are highly resistant to heat, water, and acid.

Precast Solves Many Problems

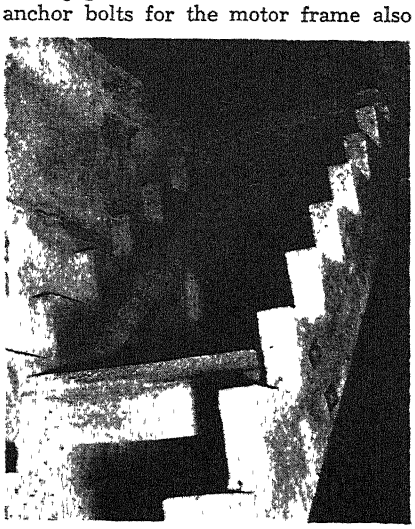
When Concrete is Precast Rather than Cast in Place, it is Possible to Accurately Control Many Desirable Qualities. In Addition, Standardized Forms Are Available Which Can be Quickly and Easily Put to Use. Concrete Products Can be Made on a Production-Line Basis

AN ELECTRICAL products manufacturer had to fit a deep tank into an odd corner of a process room. To have the necessary capacity the tank had to fill all the space available, and that space was pear shaped. Worse still, production could not be halted while a special tank was built in place and the tank had to have fair thermal insulating abilities.

Precast concrete solved the problem. A template was made of the exact space that could be used. Careful measurements were made of all floor joists and other obstructions; the tank would rest on some but had to fit around others Forms were made in the carpenter shop The tank was poured with lifting lugs cast in its walls. Then the necessary flooring was cut out of the way, the tank picked up by the shop crane and lowered into place. There was no interruption of production.

A machinery manufacturer was retooling for a new product. One of the old machines could be used, but for fastest output the shop needed special stock racks, a pedestal for its driving motor, pockets for tools, a larger bin for holding and draining chips until the scrap disposal truck came along, and other features.

Precast concrete solved this one too The planned base first was mocked-up with scrap lumber to make sure that everything would be as desired. Then the forms were made. Dowels on which the special stock racks could be fitted were cast in place, arrangements being made for lift trucks to take away empty stock racks and replace them with filled ones, with the dowels serving as positioning guides as well as anchors. The anchor bolts for the motor frame also were cast directly in place as inserts.



Stairs that will never creak

When the time came for the changeover, the usable machine was lifted clear of the floor with a crane, the new precast base was skidded into place and lowered, the machine was lowered onto its base and positioned there, the machine base was through bolted and concreted-in, the motor was installed, and the new set-up was ready for tooling.

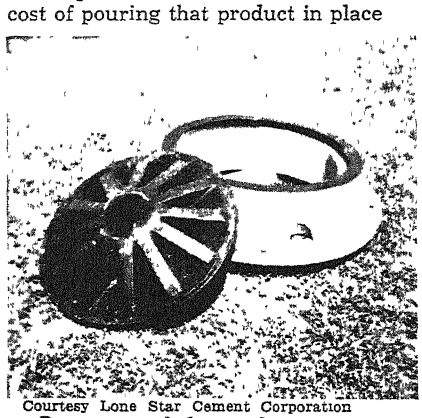
Specially designed precast concrete shapes like these have been used in industrial plants for many years. Other examples are battery boxes, forming dies, pedestals to stiffen the supports of outboard bearings, silo staves for chemicals tanks, counter weights, ballast blocks, and ducts.

READY-MADE PRODUCTS—Back of these is a line of products which can be bought ready-made from concrete products manufacturers. Blocks are part of that line, and pipe, floor slabs, wall panels, joists, lintels, cornices, manhole covers, columns, catch basins, and shingles. The products manufacturer stands ready to make the special stuff, too, and to advise about how it should be made. Thus an industrial plant has two choices. It can design and make its own precast shapes, or it can have them made almost anywhere.

The reasons for using precast are those of convenience and versatility. Not only can the manufacturer produce unusual shapes and move them into place only when he knows they are perfectly right, but also he can obtain controlled properties and qualities which are desired, perhaps, in only a few parts of his plant.

Light weight is one property obtainable in precast shapes; noise absorption, oil resistance, nailability, thermal insulation, stiffness, tensile strength, and chemical resistance are others. These same properties, of course, can be had in concrete poured in place. But when special qualities are wanted, or when there is anything at all difficult about the work, then doing the pouring in a place especially prepared for concrete production can have plenty of advantages over working where the concrete is to remain.

For standard shapes such as blocks and joists, the special precast-facilities have another advantage. They permit concrete products to be made on a production-line basis. Forms and other repetitive tools can be designed for rapid action, special materials-handling equipment designed, every advantage taken of high early strength concrete techniques to get more work from the same equipment and floor space. With repeated small savings added to big ones, the price of the finished product often is less than the cost of pouring that product in place



Courtesy Lone Star Cement Corporation

Precast manholes and covers are carried in stock, ready for quick use

Designing of precast products to secure unusual qualities offers almost infinite possibilities. Cements can be varied, as can aggregates, admixtures, surfacings, reinforcements, and mixing and placing methods. In fact, there are so many practical combinations of materials and methods in the precast concrete field that the inexperienced engineer always should seek the advice if not also the use of the production facilities of experts.

Some cements, for example, are almost pure white in color. Mixed with white aggregates, they can be cast into wall panels, floor slabs, machine bases, and so on, which give unusual reflectivity of light combined with minimum glare. Other cements are specially resistant to the sulfates—those old enemies of concrete.

High early strength concretes have the advantages of quick production. Table tops, piers for reinforcing buildings or for strengthening floors on

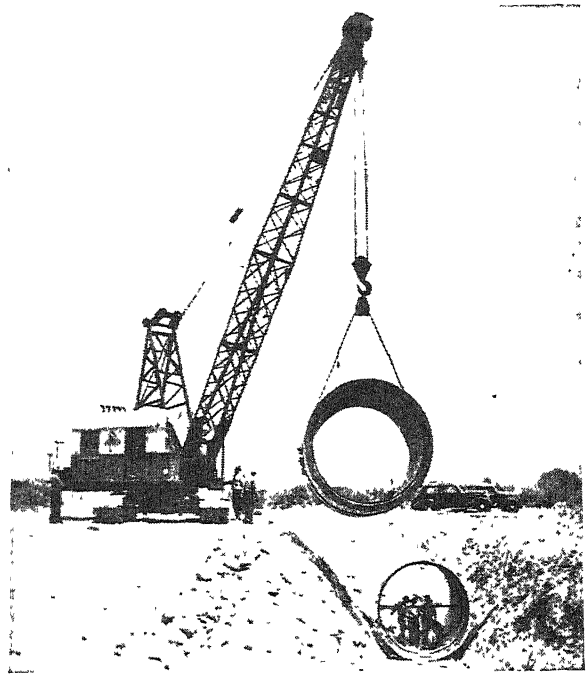
which unusually heavy loads are to be placed, and other products can be cast on Saturday and be ready for use on Monday. Thus the time interval between finding out what is needed and getting it ready for use may be reduced by weeks

Aggregates can be varied And this is perhaps the most important opportunity which precasting provides. For concretes are very largely what their aggregates make them. The cement itself is only a means of fastening the aggregates together Nearly all of the special qualities come from the special selection of aggregates

Weight is an example. By using ordinarily obtainable aggregates, concrete can be made to weigh anything from 30 to 150 pounds per cubic foot. In fact, some specializing engineers divide all concretes by two classes of weights· (1) the 80 to 105 pounds per cubic foot class, and, (2) the 140 to 150 pound class. Class 1 can be produced with such aggregates as expanded mica, expanded slag, or with clay, shale, or slate which has been expanded, or with cellular aggregates such as cinders. Class 2 can be made with stone, gravel, trap rock, limestone, dense slag, and the like.

One way to cut down on weight, and on cross-section too, is to prestress the reinforcement Ordinary concrete has great compressive strength, but a tensile strength of only about 500 pounds per square inch. Prestress the reinforcement, and the tensile strength can be brought up to 2000 or more pounds per square inch. This means that concrete sections can have longer spans between supports and can be thinner and lighter, too. In one recent test a beam with prestressed reinforcement stood four times as much as a similar one with ordinary reinforcement before breaking.

Prestressing of reinforcement lends itself peculiarly to precasting techniques. It can be done, of course, with concrete which is to be cast in place. But the prestressing means that the reinforcement is stretched—put under tensile stress—and held in its stretched position until the concrete has hardened and been firmly bonded to the steel. The stretching can be done with ordinary fence pullers for some kinds of work. But, when real results are desired, then carefully controlled methods, usually involving the use of nuts and bolts which take up exactly predetermined amounts, are used One patented method requires that the reinforcement be coated with a mastic before being placed in the forms, then be electrically heated to 250 degrees, Fahrenheit, above the temperature of the surrounding material, then tightened up predetermined amounts by the use of nuts. As the reinforcement cools, the nuts keep it from shrinking and thus provide the prestress. The mastic causes the concrete to bond firmly and uniformly.



Precast pipe can be big or small, as needed

Controlled prestressing like this is not too hard to do when everything is set up for mechanical handling of forms, and so on, and there is plenty of elbow room in which to work—conditions easy to create where precasting is being done, but not always obtainable when concrete is to be poured in place.

Admixtures can help when special results are wanted. There are, of course, plenty of construction engineers who do not believe that any admixture ever added a thing that could not have been had by proper selection of aggregates plus proper mixes and placing methods. But the admixture men point out that their products can add colors, water resistance, chemical resistance, compressive strength, oil resistance, early strength, and other qualities And the most hardened "cement and aggregate only" man in the business will admit that the admixture sales engineers hand out qualities and quantities of technical advice and engineering suggestions which are worth far more than their products cost.

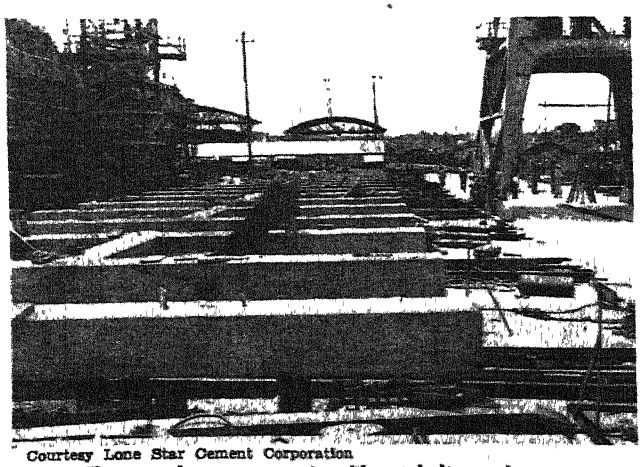
Calcium chloride is used for its effect upon high early strength. One professional precaster mixes 100 pounds of calcium chloride in a 50 gallon barrel of water, uses one bucket of the mixture to each 25 cubic foot of batch, and estimates the gain in high early strength to increase his output per form by an average of over 16 percent

Special surfacings, which can be applied while precasting products, include everything from special mixes of concrete itself to glass, steel, wood, and the like. Much of the surfacing is applied with the help of special mastics developed during the war The mastics compensate for the differences in thermal expansion between, for example, concrete and glass or steel. And they make the surfacings stay in place

Like so many other special concrete materials, surfacings are easiest to handle when applied in small amounts to precast products which are made by carefully controlled mechanical methods.

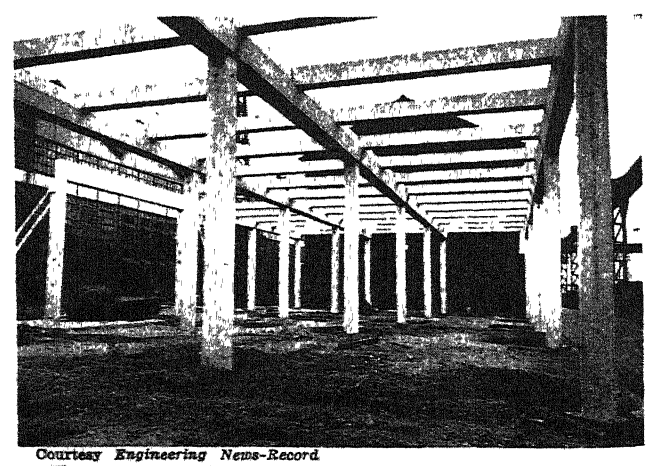
Mixing and placing methods are helped by production conditions which can be set up for precasting. For best results, concrete batches must be mixed with as much care as chemical formulas; the old fashioned combination of a "bohunk with a trough, a shovel, a hose, and a strong back" will not do. Water, for example, is measured out so carefully that the amounts contained in the sand and the aggregates are counted in.

Vibration is important to placing. With proper vibration, far less water need be used in the mix, the early



Courtesy Lone Star Cement Corporation

Shipway beams precast, with eyebolts as inserts



Courtesy *Engineering News-Record*

These precast columns and beams were delivered from stock

Chemical tanks can be quickly assembled from precast concrete staves

strength is higher, and the results are more uniform.

The frequency of the vibration is far more important than the amplitude. In fact, too hard shocks can result in elements of the mix being separated out, bad surfaces where the mix has frictional contact with the forms, inadequate cementing to the reinforcement, and other troubles.

But high frequency with low amplitude is easy to provide when production conditions are controlled as they are in precasting. A simple table top can be mounted on rubber supports, on springs, or on anything that will flex. Vibratory motion can be applied with compressed air, by attaching a high-speed imbalanced rotor, or by electrical means. No plant maintenance department has much trouble in making such a rig once it knows what is required.

With so many possible variations in production techniques, industry can have almost anything it wants in its precast concrete products.

Noise absorption is obtained by using light weight, cellular aggregates. Blast-furnace slag is one of these. Vermiculite, an expanded mica, can produce concretes weighing only 30 pounds per square foot and having high noise-control qualities.

Nailability can be had by using aggregates into which nails can be driven. Another method is to cast nailable strips into the faces of harder and stronger concretes.

Temperature control can be had by using expanded aggregates. With expanded mica, for example, K values (thermal conduction coefficients) approximating those of asbestos have been obtained, although at a sacrifice of compressive strength.

With selected aggregates and reinforcement, concrete can be increased in heat conducting ability Thus precast products can insulate to preserve heat or protect against it, or can conduct heat, as desired.

CONCRETE IN PREFABRICATION—Prefabricate-ability can be had by the control of aggregates and mixes. Precast products can be intended to be drilled, sawed, or otherwise reshaped at will after being installed.

The dividing line between the practices of pouring in place and of prefabricating seems to be in the size and the nature of the structure to be built. An ordinary flat machine base might well be the poured-in-place concrete floor on which the machine is to stand. But when there are to be recesses for vibration-absorbing pads, special noise absorption, extra stiffness, through holes for pipes and belts, steel faced gibbs for adjustments, and the like, the precast techniques have the versatility which means so much in the long run.

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FASTER FILING

Provided by New File Metals and Styles

THE ART of hand filing is staging a come-back This art was supposed to be disappearing with the advent of high-speed grinders which could be held in the hand, filing machines, more versatile tool-room machines of all kinds. But the answer of the file makers has been files which would do things which old-time files would not do.

One of the latest entries in this field is the cemented carbide file, made by Kennametal Inc., which can cut cast iron at 900 surface feet per minute and cut steel up a hardness of 62 Rockwell C.

Curved tooth files by Nicholson have their teeth so arranged that the file tends to keep itself on line. At the same time, the tooth form gives a double shear cutting effect, gets the work done at higher speeds. Files of this type are much better for comparatively untrained mechanics to use, since much of the skill in old-time hand filing was in preventing the file from running off line. Well trained mechanics find these files faster and more satisfactory for much of their work; they tend to provide more speed with less effort.

Hand filing is not likely to get back all the work it has lost to machine methods, but with these and other new files, this art is creating brand new fields for itself by making operations economical which previously were too costly

SAFER REPAIRING

Can be Assured with Simple Precautions

MORE tanks, drums, pipe systems, and ducts which contain flammable materials are in use than ever before. And under the pressure of war production schedules, the maintenance problems are increasing.

Maintenance often involves the use of blow torches, welders, and other devices which may start fires. Even worse are cold chisels, wrenches, and pliers which can cause sparks that will ignite flammable gases.

First step to prevent fires and explosions is to clean the tank. Water, steam, or a mixture of six ounces of trisodium phosphate or sodium silicate to a gallon of water, are used for cleaning. Care must be taken that the cleaning is done in the open air, or in a well ventilated place. Window or roof ventilation is not enough; flammable fumes usually are heavier than air and will flow along the floor as they are forced out of the vessel, getting into ducts, drains, and other places where they are hazardous. All open flames must be removed from the vicinity.

Another protective measure is to fill the vessel with an inert gas, or a mixture of inert gas and air. The gas must be in a concentration of at least 50 percent by volume of the contents of the vessel Higher concentration may be necessary if the vessel walls hold scale, sludge, and so on,which are likely to exude dangerous gases when heated

Nitrogen is an excellent inert gas if obtainable. More commonly, carbon dioxide is used The CO_2 should be used at the rate of one pound of dry ice or liquid CO_2 for every 17 4 cubic feet of the volume of the vessel. For example, the contents of a 15 pound CO_2 fire extinguisher is enough for a tank 10 feet long and 4 feet in diameter, holding 130 gallons of oil when filled

MASS RADIOGRAPHY

Detects Incipient Tuberculosis in Factory Workers

INDUSTRIAL workers in factories controlled by the government are now being given the advantage of chest X-rays similar to those used in examination of men for the armed forces. Results to date indicate that about one person out of every 1000 working in factories has unsuspected tuberculosis —a threat to his own health and that of all his fellow workers. Government X-ray programs so far have found more than 200,000 previously unknown cases.

The procedure is simple. Employees stand in line, walk to the portable machine, and are X-rayed at the rate of 150 per hour. Time away from work seldom is more than ten minutes per man. The cost is between 75 cents and $1 per man. Most cases found are in early stages when healing is easy. The average cost of curing a case not detected in its early stages is $10,000, most of which must be paid by charitable institutions or added to tax bills, since patients seldom have that much money themselves.

When an early or "minimal" case is found, the patient is given work which will not require too much exertion; he also is given shortened hours, rest periods, special diet. His skill and usefulness as an employee are preserved Advanced cases, of course, must have sanatorium care.

The highest percentage of cases is found among the older workers whose long-developed skills are hardest to replace. Preventing the breakdown of these men is important. But most important is the morale effect upon other employees who learn that they themselves are not infected and are not being subjected to infection

Electronics In Tomorrow's Industry

Its General Trend Will Take Three Directions—Improving Old Processes; Applications of New Principles Not Yet Released from the Secrecy Seal of the War; and Commercialization of Techniques Now Being Developed, Such as Electronic Cooking, Sterilization, Personal Radio-Telephones

Of all the industrial contributions to the war effort, the biggest expansion from pre-war status has unquestionably occurred in the field of electronics. In communications, in detecting enemy facilities and automatically aiming guns, in bombing through clouds, in spotting submarines deep under water, and in robot-like automatic controls for big aircraft, electronic tubes are today accomplishing military feats that foretell a promising post-war boom in civilian electronic applications.

Up to about ten years ago electronics had not been accepted in large plants such as steel mills, foundries, machine shops, and mines, to any extent at all As a matter of fact, it was difficult for an engineer even to get into a steel mill if he was thinking about putting vacuum tubes to work. The head of the mill might point out the rough-and-ready workmen hoisting things about the plant and ask with a laugh "What chance would a glass tube have in such an environment?" Today, however, this attitude has completely changed, and now electronic tubes are mounted right on huge punch presses and rolling mills, doing jobs so satisfactorily that shutting down the electronic controls would create a minor catastrophe among the men.

Heating a chisel point for hardening, using a 15-kilowatt General Electric radio-frequency generator that sends current through the water-cooled copper coil surrounding the chisel

Probably the outstanding attribute of electronics in heavy industry is that it can be made to function with precise action and speed, exactly the two characteristics needed to control processes, inspect parts, control power, and perform other operations that give us better products at lower cost.

The general trend of industrial electronics extends in three directions·

(1) Improvement of old processes and products by war-inspired application of electronic equipment, such as in electronic sterilization, dehydration, welding, and control methods

(2) Utilization of radically new electronic principles still under restrictions of military secrecy; such as radar locators, underwater locators and communicators, electronic map drawing devices for mobile equipment, and electronic gun-fire directors

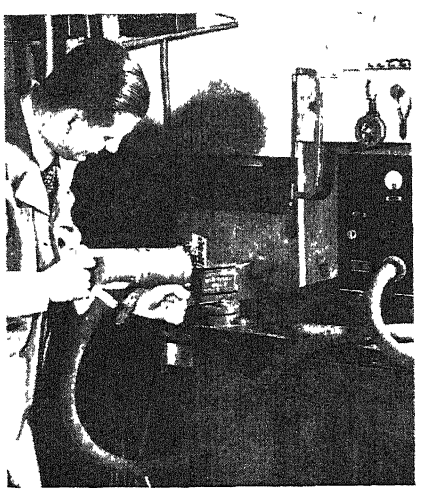
(3) Commercialization of electronic techniques now in the idea or blueprint stage, such as electronic cooking of food, personal radio-telephones, electronically glued plywood furniture, and electronic diagnosis and treatment of ailments.

ELECTRONIC WELDING GENERATORS— Welding has made tremendous advances in war-time years Most spectacular are the new techniques utilizing high frequencies produced by electronic generators. For metals, high-frequency welding produces a joint so fast that fingers held close to the joint can scarcely detect a rise in temperature, yet the resulting joint constitutes a perfect fusion even for metals hitherto difficult or impossible to weld. A butt weld of two dissimilar rods gives a smooth joint with practically no discoloring or weakening of the metals due to heat, since the high-frequency current concentrates its heat in surface layers only a few molecules thick.

For glass, on the other hand, high-frequency welding permits fusing together thick pieces for forming complicated piping systems such as might be used in milk pasteurization plants, or fusing a ground-glass disk across the end of glass tubing. The high-frequency current is here passed right through the glass, because molten glass becomes conductive

The pieces to be welded are placed between two facing gas jets whose metal bodies are connected to the terminals of the electronic generator. The current flows from one jet through the flame to the molten glass, through the glass to the other flame, and through that flame to the other generator terminal The current heats the inside of the glass pieces after they have been butted together, keeping the glass molten there long enough to achieve perfect fusion

Conventional welding has been advanced by electronics to the stage where it is now acceptable for use in such critical applications as aircraft structural assemblies. Electronic tubes known as ignitrons and thyratrons generate the surges of current that are shot through the metal in modern spot and seam welding techniques, while small tubes and even ordinary radio tubes control the magnitude and time duration of the current and voltage. The welded spots can actually be made so fast that they overlap to make a seam even better than that produced on cloth fabrics by sewing machines. Now at last it is possible to weld together thin sheets of aluminum and other metals without burning or weakening, or even weld a thin sheet to a heavy structural member—something unheard of before the war.



This RCA electronic detonator of explosive rivets is being used in aircraft plants to speed up assembly work. High-frequency currents generate sufficient heat to detonate small charges of explosives in the rivets, spreading them at the end

The extensive war-time applications of electronic welding in the aviation,

ELECTRONICS

What It Is:

Electronics is the industry based upon the utilization of glass or metal tubes in which electric current flows through a vacuum or gas. Most of these tubes closely resemble those used in ordinary radio receivers and broadcast stations, others, many of which are new and secret, bear such names as Klystron, magne tron, thyratron, ignitron, megatron, and iconoscope.

How It Works:

First—a device converts a physical change into an electrical impulse. Examples of these devices are phototubes (affected by light), thermocouples (affected by heat), vibration pickups (affected by movement).

Second—a vacuum-tube amplifier builds up the strength of the initial electrical impulses and selects the correct impulses needed for control.

Third—another device performs the desired final action in response to the amplified electrical impulses. Examples of these final actuating devices are electromagnets that reject sub-standard objects on a conveyor, and relays that turn on alarms, lights, motors, and other electrical equipment.

What It Does in Industry:

Analysis
Color Measuring
Cooking
Counting
Curing of Tobacco
Dehydration of Food
Detection of Foreign Particles
Dielectric Heating of Non-Metals
Flame Failure Detection
Gas Detection
Geophysical Prospecting
Germination of Seeds
Grading
Illumination Control
Induction Heating of Metals
Inspection
Irradiation
Killing Bacteria
Liquid Flow Control
Machinery Control
Measurement
Motor Control
Power Conversion
Preheating of Plastics
Process Protection
Smoke Detection and Control
Smoke Precipitation
Sorting
Sterilization of Packaged Food
Temperature Control
Vulcanizing of Tires
Welding
Worker Protection
X-ray Examination

automotive, and shipbuilding industries will certainly be even more extensively used in these fields and many others after the war, replacing riveting, clamping, bolting, and other fastening methods.

Whereas the foregoing welding techniques all produce the required heat as a result of actual current flow through the objects being joined, the new process of joining thermoplastic materials by welding utilizes high-frequency waves like those used in radio and communication fields. These set up molecular friction within the material, producing thereby the heat required for perfect fusion of sheets of Pliofilm and other transparent or colored sheet materials such as are used for tobacco pouches, light-weight rain capes, umbrellas, and similar products. The material is fed between two metal rollers connected to the terminals of the electronic generator, and the equipment has become popularly known as the electronic sewing machine.

To the industrialist, the important role of electronics in war production suggests new manufacturing techniques for his regular products. Such operations as electronic brazing, annealing, hardening, soldering, paint-drying, gluing, and heating will boost post-war production just as much as they are today boosting the daily output of military equipment.

HEATING COSTS—Heat generated by high-frequency power is admittedly more expensive per pound of material heated, but in hundreds of jobs the increased power cost is more than justified because it means doing a hitherto impossible job or turning out a better product faster than by older electric, gas, or steam heating methods. The high cost of electronic heat is due to the fact that the electric power taken from the power lines must be changed to higher frequencies by an intermediate power conversion unit or generator. The power tubes and associated parts of this generator are relatively costly at the present time since mass production has not yet been achieved. When post-war demands of industry create volume sales that lower cost, electronic heating units will quickly expand in scope of application.

The generation of heat in food and drugs promises to play a major role in these two industries. Three food-processing methods—dehydration, sterilization, and cooking—are even today done faster and better electronically than by conventional techniques in a great many instances. The non-metallic material to be heated is simply placed for a few seconds between two metal plates connected to the output terminals of the electronic generator, which is nothing more than an old-fashioned radio transmitter having a self-excited oscillator rather than crystal control.

By making possible wholesome food for our troops in the South Pacific and the other tropical fighting fronts, electronic dehydration is making a major contribution to our military successes. Conventional methods of dehydrating vegetables, milk, and other foods cannot remove sufficient moisture for refrigerated storage in humid tropic locations, without causing case-hardening, burning, and loss of flavor. So electronics takes over where they leave off and removes that extra 3 or 4 percent of moisture. Now even dried whole milk can be shipped anywhere without danger of its butter fat content becoming rancid, because its moisture content is reduced electronically from 2 percent to 1 percent. When the powdered milk is reconditioned by the addition of water, the liquid becomes as palatable and nutritious as fresh milk.

Considerable research has been carried out this year in electronic cooking of food. A large ham was in one instance cooked uniformly throughout in 20 minutes instead of the usual four hours, indicating great promise for this new technique in food-processing industries as well as in restaurants. In other tests, individual cold portions of chicken pie, already pre-cooked, were brought up to serving temperature in 15 to 30 seconds. In the future, this can mean elimination of efficient but flavor-spoiling steam tables for long-time warming purposes, because compact electronic warming ovens will be able to provide almost instantaneous warming, cooking, or even baking. In restaurants, table-model electronic bun-warmers will permit serving buns without the hard crusts resulting from ordinary oven storage.

Although electronic cooking has a commercial future, economic problems make immediate post-war use at home unlikely. A two-quart pot requires about the same two kilowatts of electric power for heating whether on an electric stove or between the plates of an electronic generator, but the high cost of converting ordinary power to high-frequency power is what may prevent electronic cooking from becoming a domestic science for some time.

Since electronic baking of bread gives no crust, many bakers are skeptical of electronic cooking. Chefs, too, offer objections, and suggest that uniform cooking provided by the electronic method might alter familiar flavors by eliminating juice-sealing crusts, but public acceptance of electronic flavors has not yet been tested. Bakers, however, praise controlled electronic heat for melting chocolate to simplify handling and speed mixing of cake and cookie batter. Conventional methods of melting chocolate require close watching to prevent over-heating and consequent spoilage.

Roasting of peanuts, coffee beans, and cocoa beans are other economic successes of electronic equipment. A moving

belt carries cocoa beans between the energized metal plates, and the beans often heat so rapidly that they shell themselves by an explosive action

FOOD STERILIZATION—At the present time, sterilization of food products has developed into an important job for electronic heating When equipment is available, it will be possible to take any given quantity of grain or processed food, no matter how badly infested with insects, and completely sterilize it in one treatment The sterilized material can then be stored along with uninfested material or shipped with assurance that there will be no further infestation Since the loss due to insects in grain products amounts to hundreds of millions of dollars a year, according to the United States Department of Agriculture, electronic sterilization should receive widespread acceptance in the food industry. In addition to direct savings, the process will prevent loss of goodwill of purchasers of packaged food.

The sterilizing technique for grain being prepared for storage involves running the grain on a conveyor belt between the plates of an electronic heating unit at an appropriate speed to bring the grain to sterilizing temperature. In most installations, a time of 20 to 30 seconds between the plates is enough

The instant the grain moves beyond the plates the particles receive no further heat By use of this conveyor belt technique, packaged products such as breakfast foods, baby foods, baking mixes, flour, dog food, and so on can be sterilized on the way to the warehouse or at any time before shipment Cost of the process is about a hundredth of a cent a package for electric power Amortizing, maintenance, and power costs for a typical three-kilowatt unit over a 10-year operating period amount to about 17 cents an hour of operation

Besides applications in the food industry there is another tremendous field for electronic sterilization in the drug and pharmaceutical industries, for such items as bandages, sulfa powders, sutures, and so on Notwithstanding rumors to the contrary, the equipment can be operated by anyone without risk of personal sterilization

These applications serve only as outstanding illustrations of the versatility of electronics in tomorrow's industrial world Electronics will inspect and grade materials, sort them according to color, measure and analyze vibration, control the speed of motors, regulate voltage and current, and do other things too numerous to mention It is not a cure-all and it is not magic or mysterious—but, properly applied, it is a useful science, here to stay and do its bit to make the world a better place in which to live.

Sterilizing packaged flour

flour can be sterilized as a complete unit on its way to the warehouse A heat-treat time of 10 to 30 seconds is usually adequate to develop a temperature of 130 degrees, Fahrenheit. Experiments have shown that complete destruction of all insect life is accomplished in this short time.

The cost of the heat treatment and also the power required are both low Under average conditions, about 480 one-pound packages can be sterilized each hour for 5 cents worth of power [For further details on these processes, see feature article which ends on this page —*Ed*]

ELECTRONIC FLASH

Stops High-Speed Motion Photographically

RAPID movement can be stopped photographically with a flash of about one thirty-thousandth of a second duration, produced by the Lee Strobo-Speed lamp made by Guardian Electric. A rectifier tube is employed to build up a high charge on a bank of capacitors. These capacitors are discharged in series through the flash lamp by a relay that does all the required switching automatically. One flash of this electronic lamp equals in light intensity the illumination by 20,000 ordinary hundred-watt tungsten lamps, yet the whole unit plugs into a 115-volt, 60-cycle wall outlet and fits into a carrying case scarcely heavier than a travelling bag.

LEVEL INDICATOR

Electronically Shows Amount of Material in Bin

USING an electronic amplifier, a new device for indicating the level of solids in a bin has been designed by Mosher Electronic Control System. It operates entirely on electronic principles, has no moving parts, and can be used in the measurement of all types of coarse or fine material.

The device includes two parts: a detector box which is attached to a probe extending into the bin, and a second box containing the signal control lights to show the condition of the bin level. The signal lights may be supplemented by valve control devices, sound signals, or remote control devices. The electronic amplifier measures differences in electrical capacitance between a bin that is empty and one that is full.

Lt. Col. Vogt, right, and Eino Lakso, second from left, with tire vulcanizing equipment they developed

TIRE VULCANIZER

Uses Electronics, Has Broad Possibilities

DEVELOPMENT of a tire-vulcanizing device employing electronic principles, which would enable major tire repairs to be made in 10 minutes in combat zones and which promises to become a factor in extending the service life of post-war tires to 10,000 miles, was announced at a recent meeting of the Society of Automotive Engineers.

The 500-pound mobile military unit, designed to effect repairs on any tire and to replace Army tire-repair equipment weighing tons and taking hours to operate, was described by Lt. Col. C. W. Vogt, Chief, Technical Staff for Supply, Transportation Corps, War Department, Washington, D. C. It was developed by Lt. Col. Vogt and Eino Lakso in the Forest Products Laboratory at Madison, Wisconsin, after reports from overseas had revealed that existing equipment was slow and unsatisfactory.

The device, consisting of a press ram equipped with an electrode coupled to a high-frequency generator, and a press frame, applies "internal heat" to make spot and sectional cures within minutes. The ram and frame, fitted with filler bags, which adjust themselves under pressure to tire contours, obviate the use of molds, effect repairs on any size tire, and eliminate current vulcanizing hazards such as destructive over-heating of adjacent sections.

Tests were said to indicate the possibility of utilizing the principles of the device after the war, both for recapping and for new tire production operations.

FOOD HEATING

For Purposes Other than Cooking Now Accomplished Electronically

HEATING of food products for purposes other than cooking or dehydration is receiving widespread attention today in the food industry. As one example, cakes of chocolate are being heated to the melting point to make handling easier. Another example is the heating or roasting of cocoa beans.

Sterilization of food products has developed into perhaps the most important food job for electronic heat at the present time. Whether it will continue to hold this position remains to be seen, but there is now a very imposing list of applications. The product can be treated after packaging. For example, a carton containing 24 boxes of pancake

Has The Glider A Future?

Brilliant Military Successes of Gliders in Transportation and Pilot Training Have Apparently Paved the Way to Commercial Glider Trains for Peace-Time Operation. But Closer Examination of All the Factors Involved Reveals a Number of Limitations that Must be Taken Into Consideration

IT IS A sign of the times that the Soaring Society of America has grown from a friendly group of enthusiasts to a serious organization of technicians, and that its recent Conference held at the Polytechnic Institute of Brooklyn should have brought forth a number of such scholarly, deeply technical papers, dealing with every aspect of glider art and science. The Conference comes at a time when the towed glider has proved itself invaluable in the invasion of France, when the earlier tactical uses of the glider by the Germans have been developed and surpassed by the Troop Carrier Command of our own forces, when the American armies announce the formation of an entirely new form of army—an army composed solely of airborne troops.

LARGE-SCALE GLIDER USE—Perhaps the most interesting paper presented at the Conference, at least from the public's point of view, was that of Major Eliot F. Noyes, AAF, on "The Tactical Uses of the Glider." The first large-scale military glider operation in history was the invasion of Crete by the Germans in May 1941 The most recent were the attacks on the Western Front since June 1944. A comparison of the operations is the best measure of the advances achieved in the military use of the glider. It is true that the German airborne troops succeeded where their seaborne troops perished under the blows of the British Navy, and their capture of the Maleme airdrome was the first serious blow But the scale of operations was very small, the landings were made by day only and not more than 40 or 50 gliders were sent against any one objective. A total of 70 gliders were used, carrying about 10 men each.

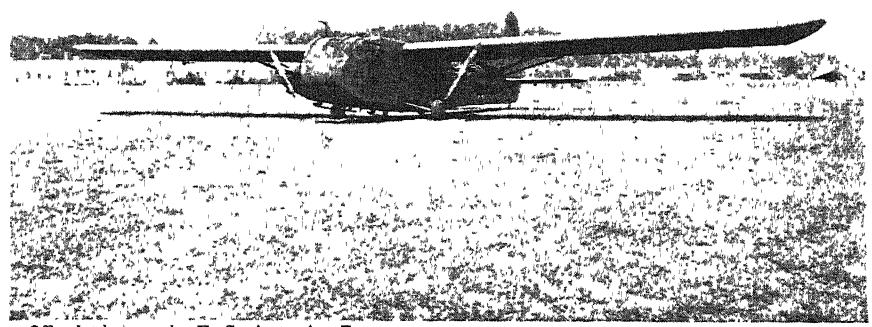
In Europe our Armies used CG-4A's carrying 15 men each, and British built Horsas carrying 25 men or heavy artillery and transport vehicles. Still bigger craft, the Hamilcars, carried airborne tanks. And, instead of 700 or so men, several whole airborne divisions were involved. These gliders landed far behind the German lines. What is more, they landed at night in rough and unprepared terrain where transports could not possibly have landed without danger of crack-up. Moreover, unlike the parachute troops, the glider-borne troops brought with them real equipment and artillery. Consequently, they were a coherent unit, capable of immediately putting up a fight. By pick-up methods the craft could be retrieved if desired.

In Burma, Colonel Cochran's Air Commandos did more; they established an airhead behind the enemy lines, and the airborne force comprised the entire assault. In other Burma operations the gliders first brought in engineers and troops who were able to lay down strips for landing and to rapidly construct the equivalent of airports. Then the air transports were able to follow. The Germans in North Africa landed barrels of oil for advanced tank units which could not have been refuelled in any other manner.

With the aid of pick-up devices the military utility of the glider can be greatly enhanced

There is a subsidiary yet important application of the glider in the preliminary training of power-plane pilots The approach to power-plane flying, by first learning how to fly in a glider, has been tested on a very large scale in Germany, Russia, and Poland. While soon after World War I the Germans turned to the glider because they were restricted in the use of power aircraft, it certainly was not on the grounds of restriction or expense that the Nazis turned to preliminary glider training in 1936—it was because German psychologists had demonstrated that the Wright brothers were perfectly right in seeking the approach to power flight by the way of glider experiments

Dr. W. R. Miles, Professor of Psychology at Yale University, stated that Germans had a lower accident index in the training of their military pilots than we had in the United States, and made a strong plea for pre-flight glider training as a method of teaching fundamental flying habits, and as a means of lowering the accident rate. Glider training, as pointed out by other speakers at the Conference, also teaches the novice the essential elements of meteorology and makes him sensitive to every gust of air, every change in the weather. It further serves to give him a confidence which power-plane flying may instill only after hundreds of hours in the air.



Official photograph U S Army Air Forces

A possible forerunner of new light-plane design—a motorized glider

Still another expert, Loren V. Petry, of Transcontinental Western Airlines, argued for the value of the glider as a background to airline flying. The glider trains in precision flying and precision landing The soaring pilot seeks thermal currents as a means of maintaining height, and in general, soaring practice makes the airline pilot a practical meteorologist.

GLIDERS AND JET REACTION—The Bazooka, the rocket bomb, the Bell jet-propelled plane, and finally the robot bomb, which has caused such infernal

damage in the south of England, have aroused the world to the potentialities of the jet as a means of propulsion Strange as it may seem, the jet has great possibilities for that type of aircraft which normally is without power. At the Conference, Mr. Zbigniew Krzywoblock spoke of "The Problem of Applying Reaction-Propulsion to Gliders."

Jet propulsion can be divided into two types: rocket propulsion in which the fuel carries its own supply of oxygen or air—as, for example, in the form of black powder—and true jet propulsion in which the fuel needs an external supply of oxygen or air. While powder rockets have dangers and drawbacks, they do not need an actual motor compressors, and so on as are required by the jet engine. Hence the simple rocket is well adapted to the glider.

Both the Germans and the Italians have experimented with powder rocket gliders, with a fair measure of success. But why should means be sought to adapt any type of rocket to the glider, since this is a vehicle of flight without power? The answer is that there are very definite advantages to be gained by the use of the rocket. Equipped with a rocket the soarer can take off from a level hilltop where no gain in altitude is required, or it may take off from flat ground, the rocket making possible the necessary gain in altitude Or rocket power may serve to prolong a soaring flight when all upward currents fail and a few minutes of rocket propulsion spell the difference between immediate descent and continued soaring. Moreover, the application of the rocket by the glider enthusiasts will give them a splendid opportunity for research in such problems as jet efficiency, the shape of the nozzle, the best explosives or fuels to use, and the like. Just as glider training leads to better pilots, the use of the rocket as an adjunct to soaring may extend our knowledge of jet propulsion tremendously

One of the old-time glider enthusiasts, Dr. Wolfgang B. Klemperer, added to the interest of the meeting by his paper on "Contributions of Gliding and Soaring to Aviation." Because gliders have to be of the highest aerodynamic efficiency, their designers adopted aspect ratios of wings far greater than those used in the airplane. Because soaring is dependent so much on aerodynamic efficiency, soaring gliders have been provided with perfectly streamlined fuselages, with wings passing uninterruptedly over the fuselage, with a complete lack of protruding control horns and landing gears, and with thin but immensely strong plywood wings In fact, it can be said that the glider is the aerodynamic school for the airplane.

These various refinements will carry over into the design of the private airplane and influence it greatly. One of the illustrations indicates what is likely to happen. Here is shown the XPG-1, which is the CG-4 glider motorized with two outboard engines.

The AAF tried out the motorized glider because that meant that a towed glider, once unloaded of the main bulk of its useful load, could fly back lightly loaded under its own power Thus the military glider, instead of being expendable, became retrievable But it is not at all unlikely that the motorized glider will lead to the design of a lightly loaded, lightly powered private airplane—particularly of the twin engine variety—which will be most important in the post-war era

A great many papers have been written in support of the idea that glider trains—two, three, or even more towed by a single powered airplane or tug—would eventually out-do even the success of the towed glider in military use by the development of such trains for commercial operation

Exponents of the glider have many arguments to offer. The Waco CG-4, a troop and cargo carrying glider, is a wonderful machine. With a wing spread of 83 feet, and an overall length of 48 feet, it weighs more than 7000 pounds fully loaded, can fly just as well at 20,000 as at 200 feet, and is completely outfitted with blind flying instruments, oxygen equipment, and so on Towed at 150 miles an hour or so, two of these gliders can be pulled by a single twin-engined cargo airplane, and thus multiply the total cargo capacity enormously. Towed to a height of 25,000 feet, they can glide 25 miles from the point of release The airplane provides the locomotive; the gliders are the freight cars.

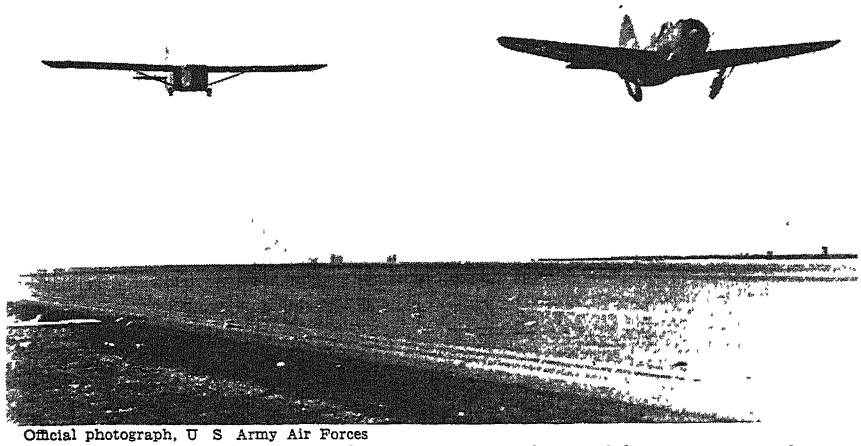
PRACTICAL GLIDER PICK-UP—Gliders can be picked up from small fields, as the late Richard C Du Pont has demonstrated on a practical scale. Gliders can be released at small fields Thus the operator of the glider train can operate with all the flexibility of the railroad man Because the cargo carrying capacity of the tow plane is so greatly increased, the costs per ton mile should go down. In fact—so say the exponents of the cargo plane—the glider will provide service for the smallest town or even village in the United States and bring air cargo costs down unbelievably Look at what the towed gliders have done in carrying military cargoes all over the world!

ON THE WRONG TRACK—While this writer accepts a good many of these arguments and approves of the sincere enthusiasm of the glider exponents, yet he believes that they are completely on the wrong track and that only in a few isolated instances will commercial glider trains be at all practicable

It is true that the towed glider will increase payload capacity, but it will also decrease the cruising speed to a marked degree. And, unfortunately, decrease in speed means a large increase

Official photograph, U S. Army Air Forces

Glider troops splay out about the nose of their silent winged carrier



Official photograph, U S Army Air Forces

Exponents of future air trains base hopes on military glider-towing operations

in carrying costs per ton mile. When the speed goes down the pilot has to receive more pay for a given distance, the insurance costs per mile go up, the block-to-block speed goes down so much that the speed differential of the airplane is cut in half. All costs or almost all airplane costs vary inversely as the speed, a point which glider people seem to overlook. Then again, blind flying is quite difficult in the glider and it must be equipped with an expensive automatic pilot.

Each glider must carry its own pilot or pilots so that crew expenses for a train go up very greatly. There is no inherent cargo-carrying virtue in the glider. If we choose to build a transport with huge cargo-carrying capacity, large aspect ratio wings, and so on, we could secure in the transport all the virtues of the glider without its drawbacks. The most serious studies made by the airlines and others indicate that the sky train is not likely to be realized Besides, there are other difficulties. Will passengers ever consent to being cut loose in a glide to earth or being picked up and launched by a species of catapults. Can it be believed that the small towns of the United States will indefinitely remain without the airport or landing field facilities which will render the glider train and pickup of far less possible value?

It is this writer's belief that the value of the glider in military and naval aviation is thoroughly well established. That as a training method for pilots, nothing can be better than prior experience in gliding and soaring. That gliders will foster refined aviation instruments and much valuable meteorological knowledge That gliders form a splendid sport which could be followed profitably in many colleges and even high schools. That the ultra-refined design of the glider will have a beneficial influence on the development of the low-powered private airplane.

The glider in its technical, educational, and military aspects deserves every support and encouragement by the Congress and by the people of the United States. But, regretfully, the conclusion must be recorded that the sky train is better adapted to the production of thrilling magazine articles than to the solution of our air transport and cargo problems.

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AVIATION'S FUTURE

Previewed by a British Aviation Expert

RARELY are reports made which are as comprehensive and farsighted as that contained in a paper on the "Future of Civil Aviation," read by Sir A. H. Roy Fedden before the Royal Society of Arts in London. Sir Roy is one of the best informed and most distinguished aviation men in England.

When the terms for Germany and Japan are being discussed, the following sentence strikes home: "It is believed that our first requirement is a steadfast determination that whatever rules are drawn up for the future are rigidly maintained, and if necessary we must be prepared to fight again to enforce them. It is suggested firstly that for at least 25 years, neither Germany nor Japan be allowed to design or to make any aircraft whatsoever either in their own countries or abroad."

In Sir Roy's discussion of International Freedom of Passage is another striking sentence: "Public opinion in this country and in the United States, it appears, is in favour of this being put on a proper basis, so that the civil transport aircraft of any country will have the right to cross any other (except perhaps over certain small restricted areas) and to land for refueling, or emergency purposes, but not for loading or discharging traffic except as may be authorized under reciprocal agreements." The more freedom there is for traffic at sea and in the air, the fewer passport regulations and custom barriers, the fewer jobs for officials, and the greater the chance for international knowledge and amity.

Those parts of the paper which deal with British civil air control concern us less, but there are many technical views and analyses of value Frequent mention has been made of the thought that there is a limit beyond which the airplane is too large and loses efficiency But the curve of efficiency against size is very flat, and the author thinks that we can go on building bigger and bigger airplanes without fear for a space of at least 15 years. However, it is probable that a land airplane over 250,000 pounds in weight should not be attempted just yet

For transatlantic work, Sir Roy favors large flying boats of at least 300,000 pounds weight Special docks would be built for handling such flying boats with minimum time for loading passengers or cargo. To keep pace with long-range operations, fuel consumption of our engines must go down to only 38 pounds per horsepower-hour Reciprocating engines for aircraft may well go up to 5000 horsepower Regarding the gas turbine: "There is no doubt that the advent of the gas turbine will give an altogether fresh impetus to high-speed, high-altitude flying in large civil aircraft, and it will be most interesting to watch this whole development come to fruition within the next ten to fifteen years" Another argument advanced in favor of the gas turbine is that, owing to its more flexible design, it can be tailor-made to fit the needs of a particular airplane

All in all, the paper is most encouraging. In the opinion of one of our greatest experts, post-war civil aviation holds magnificent prospects for the public and fascinating research and development problems for the engineer, designer, and inventor

AIRPLANE CATEGORIES

Would Facilitate Growth of Private Flying

BESIDES facilitating insurance and time purchases of private aircraft, there are many other attempts to facilitate the growth of private flying, such as the building of many airports and landing fields. Now Fred M. Lanter, Director of Safety Regulations of the C.A.A., outlines a system of placing airplanes in categories Why should all airplanes be strong enough to withstand acrobatic maneuvers? Why should a stable, well-designed transport be designed to withstand the violent maneuvers which have to be met only by machines of the training plane type?

The suggestion is that it should no longer be necessary to build all types of aircraft to the same strength requirements There would be introduced the following categories: acrobatic, training, general purpose, transport, and special purpose. Top strength would go to the acrobatic class, while training planes would come next. Only the transport airplanes would be required to have certain features essential for scheduled operations With such classification—which is *not* relaxation of the safety rules—private planes would be able to carry added fuel or baggage or passengers as the case might be.

Glowing Color In The Dark

The War Effort Has Stimulated the Development of an Extensive Line of Luminescent Pigments. These are Now Used in Paints and Coatings, Paper, Plastics, Printing Inks, and Pastes, Foreshadowing a Number of Interesting Peacetime Possibilities for Luminescent Products

By M. A HEIKKILA
New Jersey Zinc Company

THE PHENOMENON of photo-luminescence has been known for years, but until a comparatively recent time it was principally of scientific interest, and found only limited commercial application, one of the most important of which is the so-called fluorescent lamp, introduced just before the war Under the impact of the present war effort, however, scientific study and development in the field of photo-luminescence was accelerated, resulting in a large number and variety of practical applications.

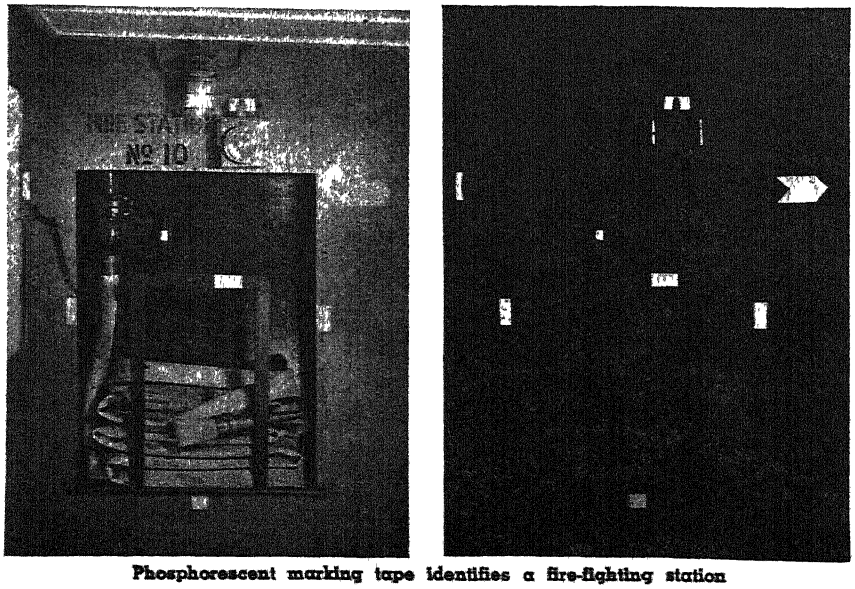
Photo-luminescence is the term generally applied to the absorption of some form of radiant energy, usually ultra-violet light, the transmutation of such energy to another wavelength, and the re-emission of such energy as light, usually visible light. This is often referred to simply as "luminescence."

The theory of the phenomenon of luminescence is that it results from the absorption of energy within the molecular structure of the material exposed to the excitation of a suitable source of radiant energy, each quantum of energy raising an electron to an upper level, from which it returns, either immediately or after a period of time, to its equilibrium state, simultaneously releasing the energy in the form of visible light.

There are two types of luminescence: (1) *fluorescence,* or the luminescence which continues only during the time of exposure to an exciting light source, and (2) *phosphorescence,* or the luminescence which continues for some period, from a few seconds to several hours, after the exciting light is extinguished. Fluorescent materials, therefore, have no afterglow, and are distinguished from phosphorescent materials which, in addition to fluorescing, have a useful afterglow. Radioactive materials, which are self-activated, are not included in this discussion.

EXCITING LIGHT SOURCES—It is obvious that the correct use of luminescent materials requires the employment of a suitable light source In general, fluorescent materials require a light source which emits very little or no visible energy if their fluorescent light is to show to best advantage An ultra-violet or so-called "black" light source, which contains a large amount of energy in the spectral range from 3200 to 4000 Angstrom units, is suitable Ultra-violet light sources include argon glow lamps, regular fluorescent lamps, special "360BL" fluorescent lamps, high pressure mercury vapor (arc) lamps, and ordinary tungsten filament lamps (operated at high filament temperatures). Suitable ultra-violet filters should be used to eliminate nearly all traces of visible energy.

When phosphorescent materials are used only for their afterglow properties, light sources containing appreciable amounts of visible energy may be used for excitation to phosphorescence. Sunlight is therefore a most efficient and satisfactory exciting light with the afterglow effective in the dark. This is true also of the illuminating systems—fluorescent and incandescent— in regular use today.



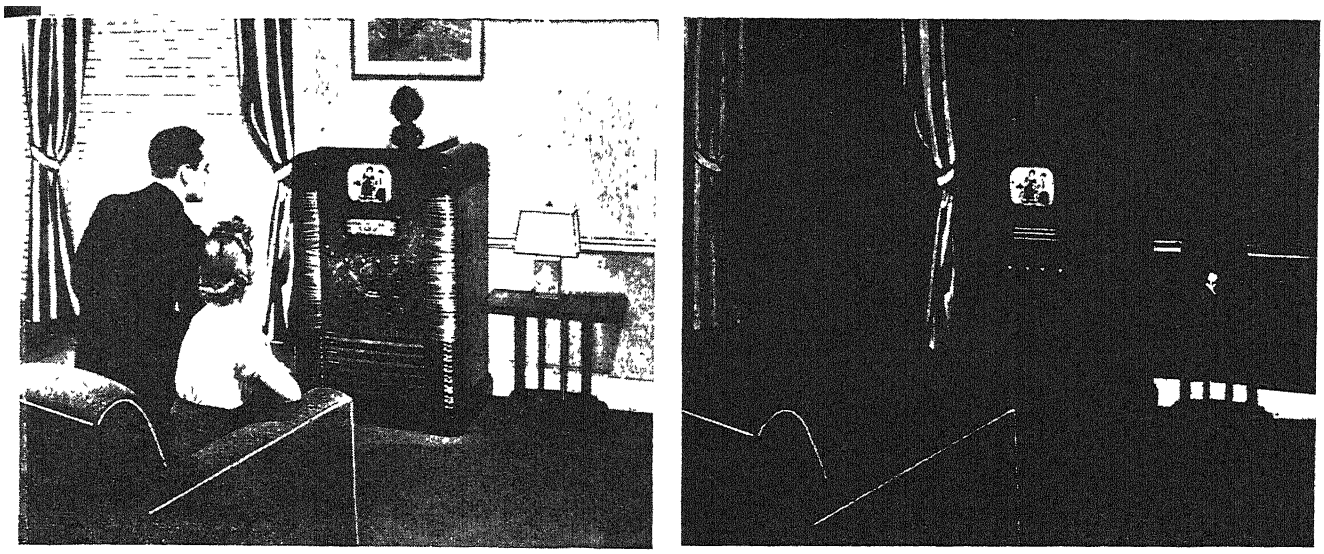
Phosphorescent marking tape identifies a fire-fighting station

FLUORESCENT PIGMENTS — Fluorescent materials generally are divided into two groups, based on their chemical composition· (1) organic, which includes synthetic dyes, dye intermediates, and metallic salts of dye intermediates, and (2) inorganics, which are generally the sulfides of zinc, or combinations of zinc and cadmium sulfides.

The dyes include such coloring materials as rhodamine, eosine, and flavine, and are obtainable in colors covering the range of the entire visible spectrum. They have the desirable property of a color similarity in the fluorescent and daylight colors, but these colors are not fast to sunlight or daylight.

Somewhat more stable fluorescent materials may be prepared by precipitating the dyes on a suitable inorganic base, such as aluminum hydrate, to form lakes. Very little research on these types of fluorescent materials has been done, and their full characteristics are as yet unknown.

Considerably more stability on exposure to sunlight is obtained with metallic salts of dye intermediates, of which the zinc salt of a 8-hydroxy-



Luminescent draperies, wall coverings, furniture trim, molding, and baseboard as guides in a darkened television room

quinolin is an outstanding example. Available in powder form, this material is white in daylight color, and exhibits brilliant green fluorescence.

The most useful and stable fluorescent materials are the manufactured inorganic pigments which are produced under conditions insuring the greatest possible purity. Very small and controlled amounts of activating heavy metals, such as copper, manganese, or silver, are included in the pigment. (These activating metals act as energy centers in the molecule.) The pigments are prepared by calcination at relatively high temperatures, and as a result their particle size is somewhat coarse as compared with ordinary pigments. (The average particle size of these fluorescent pigments is about one micron, approximately 1/25,000 inch.) The daylight color of these pigments varies from white to yellow, while the fluorescent color ranges from blue to red. In general, the orange and red are highest in cadmium sulfide content, and lowest in fluorescent brightness.

PHOSPHORESCENT PIGMENTS — Phosphorescent pigments are essentially inorganic pigments. They may be divided into two groups: (1) those having a short afterglow (up to two hours) and (2) those having a long afterglow (6 to 10 or 12 hours and more).

The short afterglow phosphorescent pigments are zinc sulfides and combinations of zinc and cadmium sulfides. They are prepared in much the same way as the fluorescent inorganic pigments, except that they are calcined at higher temperatures, with a resultant coarse particle size. These pigments are quite stable and are obtainable in light green, yellow, and yellow-white daylight colors with brilliant green and orange-yellow phosphorescence.

The long afterglow phosphorescent pigments are calcium and strontium sulfides, prepared by calcination at high temperatures. They are very coarse in particle size, and in addition are sensitive to moisture, requiring care in processing if exposure to moisture in use may be expected. These pigments come in daylight colors of gray-white and light green, and exhibit violet, blue, and greenish-blue phosphorescence.

APPLICATIONS—The development and application of luminescent pigments for war purposes were motivated principally to provide: (1) low intensity illumination for night operations, (2) signal devices, and (3) emergency light sources in the event of power failure or black-out.

In night operations, the luminescent pigments serve two purposes. They permit a "working" amount of visibility without the use of normal light sources, and they protect the dark adaptation of the eyes of operators of equipment. For these purposes, luminescent pigments are employed in paper, printing inks, paints, and plastics for the manufacture of military maps and charts, instrument dials, navigational computers and calculators, instruction plates, correction sheets, and so on, for use by airplane pilots, navigators, and bombardiers, P-T boat pilots, field officers, and by other personnel of the armed forces.

Fluorescent zinc sulfides and zinc and cadmium sulfides are the pigments that have found most use in these applications. They can be ground on roller mills to make reasonably satisfactory paints and printing inks, can be dispersed in paper or plastic coatings by mixing or colloid milling, and can be dispersed in paper finishes in the beater and in plastic granules in the batch mixer.

Phosphorescent pigments—both the short and the long afterglow pigments—are the ones principally used as emergency light sources, although they are also employed as instruction plates, signs, and in similar applications. Phosphorescent coated adhesive tapes are used extensively aboard ships and in the field to provide sufficient light to permit movement and easy identification of equipment and supplies in the dark without the use of normal lighting. Long afterglow phosphorescent pigments are used. These pigmented tapes are kept excited by exposure to daylight or to the normal lighting system in use, and will continue to glow and be visible to dark-adapted eyes throughout the dark hours of the night. Signs and instruction plates, of course, are used under similar conditions.

POST-WAR USES — The restrictions caused by the war have prevented any great amount of pre-peace experimentation and development of post-war applications of luminescent pigments, making it difficult to arrive at any definite conclusions of coming civilian uses for these glowing pigments. There are, however, a number of indicated applications for luminescent pigments that appear logical, including

PHOSPHORESCENT
(Excited by daylight exposure)
Apparel accessories
Architectural trim
Automotive accessories
Cord pulls (lights and window shades)
Decorative floor, furniture, and wall coverings
Displays and fixtures
Door knobs and kick plates
Electric switch plates, fixtures, and equipment
Escutcheons and medallions
Fish lures
Games
Jewelry
"Juke" boxes
Light diffusers
Marking tapes
Product packages and labels
Slipper tips
Tools

FLUORESCENT
(Excited by "black" light exposure)
Automotive and aviation dials and accessories
Charts and maps
Decorative coverings
Displays and advertising
Drapery
Light diffusers and color transmuters
Murals and decorative designs
Paper specialties
Theatrical effects

Undoubtedly, as usually happens, the public will find uses which the manufacturers have not envisioned—some of them perhaps more important than those which have been discussed here.

Rays That Sterilize

Wherever Industrial Operations Require a Bactericidal Effect for Sterilizing Air, Packaged Goods, Utensils, Containers, and so on, There Will be Found A Field for Application of Ultra-Violet Radiation. The Use and Measurement of these Rays is Becoming Rapidly an Exact Science

By DR HARVEY C RENTSCHLER
Director of Research, Westinghouse Lamp Division Bloomfield New Jersey

OF ALL the marvels of divine handiwork, the sun shines forth as the brightest; laboratory workers who daily are trying to simulate its remarkable qualities are the best witnesses of that fact

Sunlight sustains life, makes possible the normal development of plants and animals and at the same time has an amazing purifying effect, killing bacteria and other micro-organisms. It is the bactericidal effect of sunlight that has been duplicated in the ultra-violet tube called the Sterilamp. The radiations of this lamp speedily kill surface and air-borne bacteria, viruses, and mold spores. Hundreds of thousands of these lamps now are on guard in a wide variety of fields where destruction of these things are vital or desirable.

The Sterilamp's bacteria-killing radiations are invisible and it may be helpful to outline here the various bands of visible and invisible light.

Visible light, ranging from about 8000 to 4000 Angstrom units—an Angstrom unit is equal to 1/10,000,000 millimeter, or about a 1/250,000 inch—is separated into bands of different wavelengths which produce the characteristic spectrum or colors of the rainbow.

The ultra-violet spectrum, which ranges from 4000 to below 1850 Angstrom units, is similarly subdivided into bands which have varied effects, both physiological and chemical. There are four recognized bands of ultra-violet wavelengths, characterized by the effects which they produce. The four bands are:

1. The near to visible ultra-violet band, 4000 to 3300 Angstrom units, produces fluorescent and other photochemical effects, and is useful in photography. This band is transmitted by most ordinary glass

2. The erythemal range, 3350 to 2800 Angstrom units, produces sunburn and tan and develops vitamin D Sun lamps deliver most of their ultra-violet radiation in this range, as it is the range used largely for therapeutic treatments. The shortest wavelength reaching the earth from the sun is approximately 2950 Angstrom units and only a very small part of these wavelengths is transmitted through ordinary glass.

3. The bactericidal band, 3000 to 2000 Angstrom units, is most effective in killing micro-organisms such as bacteria, molds, yeasts, and so on, whether in the vegetative or spore stage. Special glass or quartz is required to transmit these wavelengths and the maximum bactericidal effect is obtained at about midway in this range. Practically, this maximum is at about 2650 Angstroms and close to the 2537 Angstrom resonance radiation for electrical discharge through mercury vapor at low pressures

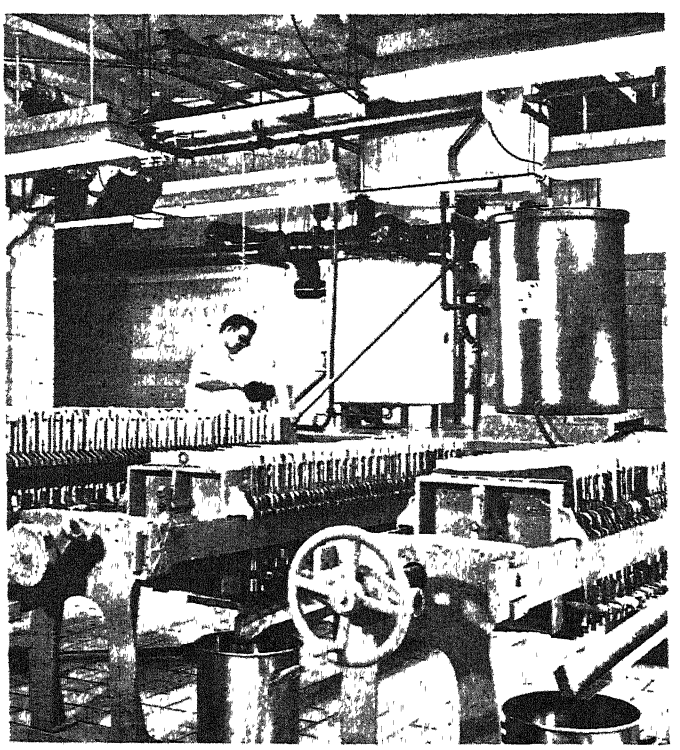
4. The ozone-producing range, below 2000 Angstroms, has the ability to convert a portion of the oxygen of the air into ozone (O_3) which is an active oxidizing agent.

In order to determine the killing efficiency of ultra-violet in the bactericidal band, a suitable measuring device had to be developed. Segregating characteristic parts of the ultra-violet region always had been difficult.

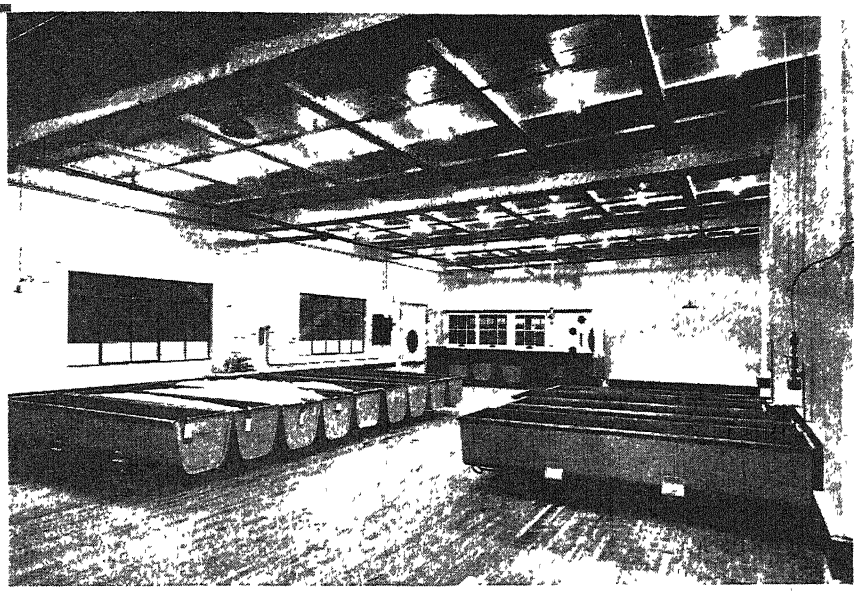
It was observed that various metals reacted differently to the photoelectric effects of ultra-violet waves. After many experiments, certain metals were selected which responded to useful groups of the invisible ultra-violet waves

SPECIALIZED PHOTOCELLS—A phototube with the cathode surface of thorium was found to have a photoelectric response ranging from 3675 Angstrom to 2000 Angstroms, covering the general ultra-violet spectrum Zirconium responds photoelectrically to wavelengths shorter than 3150. Such a cell, in proper transmitting glass, has a response very similar to the erythemal sensitivity and is useful in measuring erythemal and vitamin D radiation of sources having a high percentage of visible and near ultra-violet without having to mask the shorter wavelengths by filters.

As a photocell cathode, tantalum is sensitive to radiations below 3000 Angstroms, with a maximum at about 2600 Angstroms when cell is made with proper glass, thus confining its measurement activity to wavelengths having bactericidal action. Platinum responds only to radiations below 2000 Angstroms and thus becomes a useful cathode in a phototube for determining the amount of ozone supplied by any ultra-violet generator.



Ultra-violet bactericidal lamps in ceiling fixtures purify the air in this room where blood plasma goes through filter presses



Air-borne contamination is reduced in a bakery dough room by ultra-violet radiation

Used in connection with a special "click" meter, these phototubes make possible the quantitative measurement of various bands of ultra-violet. Radiations falling upon the sensitive cathode of the phototube permit electric current to flow through the tube and charge a small condenser. When this charge reaches a predetermined value, it is discharged through a relay tube which, in turn, operates a counter. The condenser automatically begins to store another charge and the rate at which this charge is accumulated is determined by the intensity of ultra-violet radiation striking the phototube's cathode. Each unit registered by the counting mechanism, indicated by an audible click, represents 220 microwatts per square centimeter on the standard meter.

Although nearly all the bactericidal wavelengths in sunlight are filtered out by the upper layers of air, the germ-killing effect of sunshine has been recognized for ages. This explains the potency of electrically generated ultra-violet radiation adjacent to the point where the purifying effect is desired. Bactericidal radiation can pass through many feet of air yet effectively kill floating disease germs and other organisms.

As a result of experiments with the click meter, the intensity of radiations multiplied by the time of exposure in seconds required to kill many types of organisms was determined These tabulated values provide the basis for reliable estimation of the number and location of Sterilamps required for various applications.

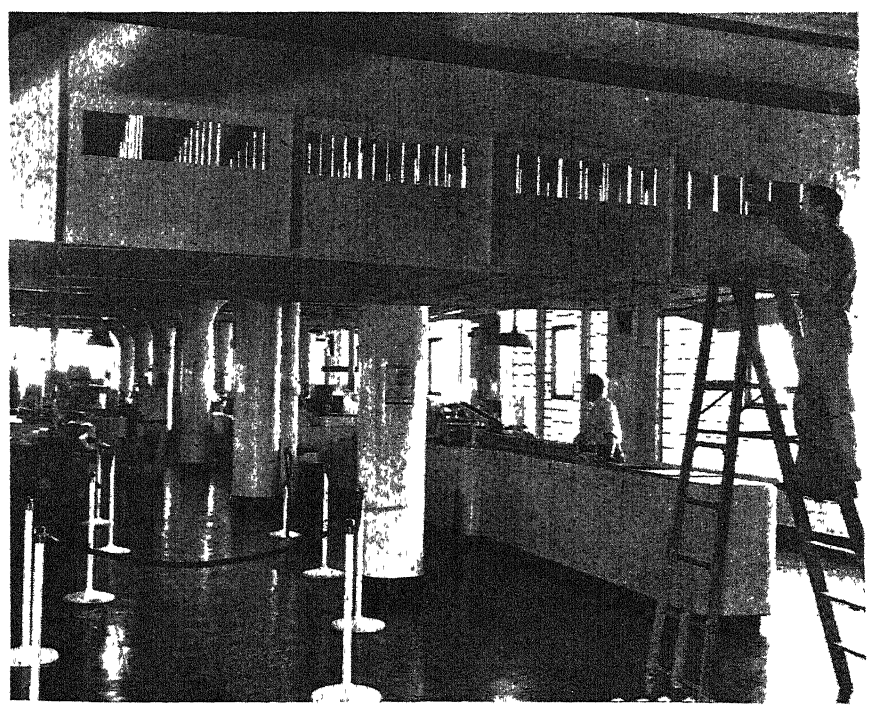
The ability to generate and control ultra-violet radiation inexpensively has greatly increased the number of applications in general sanitation. Heretofore, there has been no practical way of purifying the air which circulates in a building, school, office, or home. Now it is possible to install ultra-violet lamps which materially reduce the bacteria count in the air.

LOCATION OF LAMPS—The lamps are located above eye level. This has a double purpose—shielding the eyes from the rays which can cause conjunctivitis in eyes unprotected by goggles and placing the lamps in the upper area of rooms, where convection currents carry the organisms. Tests have shown that the number of living organisms in an irradiated room is readily reduced by about 75 percent and that there is a greater reduction in the number of cross infections in a room where the upper area has been irradiated compared to similar rooms which have not been irradiated.

The ultra-violet rays which are effective in killing air-borne and surface bacteria and mold also are capable of penetrating water to a limited degree. The transparency of water differs in different localities because of the varying amounts of chemicals and suspended matter contained. For this reason, it is recommended that water be filtered to remove solids before being irradiated. One treatment consists of placing Sterilamps over a flat trough carrying water at a depth of not more than six inches and allowing a flow of not more than ten gallons per minute per lamp For general use a reduction of 99 percent or more of bacteria count is satisfactory unless the original contamination is high In the water tanks of railroad coaches and dining cars ultra-violet radiation can help to purify the water supply.

Any product which must be manufactured or packed under sanitary conditions requires protection from air-borne organisms. Such protection is being supplied by ultra-violet radiation For example, baked goods come from the oven essentially sterile on the surface and may be kept in this condition by being cooled in a room in which the air is irradiated before coming in contact with the product. The wrapping operation also should be kept under ultra-violet radiation to insure that the package leaves the bakery free of partly developed colonies of mold

The commercial value of protection by ultra-violet radiation has been demonstrated further by the success of the "Tenderay" process which speeds the tenderization of beef. Tenderizing beef is a slow, natural process whereby the connective tissues or collagens break down into gelatin. It has been known that this process could be accelerated by increasing the temperature and humidity of the storage room but such acceleration was impractical because of the greatly increased rate at which slime and mold developed on the surface of the beef The difficulty was that losses due to necessary trimming of the spoiled surface made the speedier aging too expensive. Sterilamps installed in meat storage rooms guard against mold and slime, prevent spoilage, and eliminate discoloration of the beef during the two or three day period required to tenderize at increased temperatures



Germicidal lamps installed in an air conditioning duct

All photos courtesy Westinghouse

Under the protection of ultra-violet radiation, lines of Pepsi-Cola bottles are maintained in a sterile condition until they are filled and capped

Any effective and inexpensive method of purifying air has applications reaching into nearly every conceivable commercial field. Results accumulated in recent months prove the economic advantages of irradiating the air in incubators for chicks and poults. The reduction of air-borne organisms gives the chicks a better start Continued irradiation after their early hours of life produces better weight development, better pigmentation and feathers, and reduces cannibalism. This provides evidence that a small percentage of radiations near an invisible ultra-violet region stimulates vitamin D absorption with assimilation of calcium resulting. Laying hens are stimulated to greater egg production in irradiated hen houses.

The health of other farm animals also is benefitted when they are protected by ultra-violet radiation Pharmaceutical manufacturers who maintain animal laboratories for production of serums and vaccines have installed bactericidal radiation in their animal rooms as an additional sanitizing agent.

Past experience with ultra-violet radiation largely has been directed toward determining where limitations exist in its application. Throughout most of this century Boards of Health have studied ways and means of purifying urban supplies of water and milk. Public attention has been called to the need and desirability of supplying clean drinking glasses at soda fountains and bars as well as supplying sterile tableware and dishes in restaurants. The recontamination of such utensils by air-borne organisms while they are stored after rinsing has had scant consideration and no means has been available for such protection. Now the sterile storage of restaurant and bar equipment may be accomplished easily and cheaply by providing ultra-violet radiation in the storage cabinets.

Air circulating from heating and cooling systems is a constant source of distribution of both harmless and pathogenic organisms which are given off by human beings. Filtering does not remove all of these living organisms and the best means of supplying pure air to the various rooms and apartments is by passing the circulated air through a radiation chamber containing high-intensity bactericidal rays.

GERM-FREE AIR—By this method, the air entering any area may be made practically germ-free and the air supply certainly becomes a source of pure air rivaling the results which would be obtained if there were no recirculated air in the system and the entire supply were from some remote mountain top.

Recirculation of air without bactericidal treatment doubtless will soon be considered as unsafe as the use of unwashed glasses at a soda fountain. Offices without air conditioning or air circulating systems will be equipped with upper zone radiation which kills organisms floating upward on convection currents into the radiated area. Such protection, resulting in a reduction of the bacteria population, has been found to reduce materially the number of absentees and the total number of days' lost time in industrial plants. Schools are equipped with ultra-violet radiation to reduce epidemics of measles, mumps, chicken pox, and so on.

Radiation in private rooms, wards, and operating rooms of hospitals will become as widespread and essential as the cleaning of the walls and floors. The benefits of radiation in hospitals thus far reported justifies the prediction that means for more and more bactericidal radiation will be provided in the plans for future hospitals.

All in all, the sanitation of air by bactericidal radiation is destined to become one of the prime elements in the development of a stronger and better race.

RESISTANCE WELDING

Is of Greatest Value When "Engineered"

A RECENT statement by Floyd E. Taylor, President of the Resistance Welder Manufacturers' Association, contains timely advice for manufacturers now thinking in terms of improvements and economies for their post-war products.

"As the tremendous advances in resistance welding techniques on all types of metal war equipment manufacture begin to be known, makers of a wide variety of products from instruments to heavy machinery are naturally beginning to figure where and how welding may be applied to their problems," states Mr. Taylor. "Actually, there are few types of metal products wherein resistance welding processes will not play increasingly important roles. When the full story of war developments can be told, even men who thought they knew 'all about welding' are going to be amazed.

"The big point to remember, however, is the fact that resistance welding is not something to be thought of at the last minute, when products are just about ready to be put into production. Actually, resistance welding scores its biggest economies and manufacturing improvements when the product itself is designed for welding. Welding can, of course, be adapted successfully to many present designs—and often has been. On the other hand, design engineers who think in terms of resistance welding while designing their products may be pleasantly surprised at the far greater degree of efficiency that may be achieved."

Among the types of products cited by Mr. Taylor wherein resistance welding processes are progressing rapidly are· radios and other electrical appliances; such small items as optical frames; watches; vacuum tubes; alloyed wire fabrications; cutlery; tools, hardware—as well as larger products such as truck axles; refrigerators; washing machines; and many others in addition to the more conventional applications.

GLASS FIBER INSULATION

Lightweight Incombustible Material For Sound-Proofing

GLASS fibers with a diameter measured in ten-thousandths of an inch, and weighing only four one-hundredths of a pound per square foot when bound with a thermosetting resin and formed into half-inch-thick sheets, are being used in the cabins and flight decks of certain types of United States war planes to provide insulation against the extreme cold of the stratosphere and to deaden fatigue-causing sound.

Particularly on long flights, it has been found that a high sound level within the plane is one of the major factors contributing to the fatigue of the crew. With planes operating at altitudes where temperatures of 60 degress below zero are commonly encountered, insulation is necessary to reduce the burden on heating equipment and permit lighter equipment to be used.

The fibrous glass sheets are incombustible and are the lightest inorganic material commercially available for sound-proofing and insulation. Another important factor is that the sheets gain less than 1 percent of their own weight from moisture in the air, when subjected to temperatures of 125 degrees, Fahrenheit, and 90 percent relative humidity. Organic material frequently used for heat and sound insulation in planes may gain as much as 40 percent of its own weight from moisture pick-up under service conditions.

The fibrous glass sheets, known as Fiberglas Type XM-PF, are manufactured by Owens-Corning Fiberglas Corporation.

SKID-PROOF COATING

Made of Sprayable Mixture of Synthetic Rubber and Cork

A non-skid airplane walkway coating that is less than one fifth the weight of rubber matting, adheres to metal, plywood, and painted surfaces, remains flexible at temperatures ranging from minus 20 to plus 160 degrees, Fahrenheit, and is resistant to fire, gasoline, aromatic fuels, salt water, oils, hydrau-

Skid-proofing a catwalk section

lic fluids, and oxidation has been developed by the Minnesota Mining and Manufacturing Company for use in Allied war planes Made of Thiokol synthetic rubber and ground cork, this new non-skid surfacing material is applied at room temperature with an open nozzle paint spray gun, making for speedy application as well as rapid repairs in the field. It can also be applied with a knife or brush, and patches so placed blend well with the original coating.

In exhaustive laboratory tests as well as field trials during bombing raids over Europe and patrol work under extreme high temperatures in the South Pacific, this new Thiokol-cork composition has stood up extremely well. Abrasion resistance has been tested both by Calibrase wheel and by a special floor panel which showed virtually no sign of wear after passage of 100,000 people over it The tendency of this Thiokol coating to gain weight through moisture absorption is also slight. In laboratory tests, the absorption was 2 9 percent after four hours constant immersion and rose to only 28.6 percent after nine days.

One of the most important properties of the new coating material is its high coefficient of both static and sliding friction even when covered with water or a film of engine oil.

Only one spray application is necessary to build up a Thiokol-cork coating of sufficient thickness. The material dries so rapidly that the panels are ready for actual use within 12 to 14 hours.

With its light weight and speed of application this material promises to be not only a valuable war material for airplane use, but also to have many useful post-war applications in the aviation, automotive, and home fields.

HEATING BACKWARD

Can Solve a Variety of Problems

THE boiler in the heating system of the Naval and Marine Reserve Armory in Los Angeles is hooked up backward! The return water is brought into the top of the boiler and the supply at the bottom. This unconventional method of heating came about as the best solution to a variety of problems.

In the first place, a hot-water system was chosen by the heating engineers since it seemed the most practical way to heat the training areas and the mess rooms in the basement where head room was too low for duct-work. Supply and return pipes, which could be concealed in the ceiling with a hot-water system, solved this problem easily.

Second, if an ordinary hot-water system with a conventional boiler hook-up had been installed, the combination of static pressure and that from the pumps would have been just enough load on the boiler to require the services of a janitor—since state laws say there must be a janitor for any system with a boiler using over 15 pounds pressure and having more than 10 horsepower.

In the "backward boiler" system which the heating engineers finally evolved, the water which enters the top passes through a header similar to a steam header. The circulating pump is located on the supply side, thereby creating a suction and thus lowering the pressure on the boiler.

Connected to this unusual central heating system are 22 Trane blast coils located in two fan rooms—one in the basement and one on the top floor mezzanine. They provide comfortable conditions for each type of activity carried on in the huge armory, which provides training accommodations for some 400 men.

QUICK ACTING BRAKE

Uses Magnetism for Release

CAPABLE of stopping a one-eighth horsepower motor traveling at 16,000 revolutions a minute in less than six turns, a new magnetic brake has been developed by Chester I. Hall, General Electric engineer.

"Another way of expressing the force with which this new brake works can be gained by comparison with an automobile," Mr. Hall explains. "The outside edge of this rotor, moving at 16,000 revolutions per minute, is traveling a 62 miles per hour. Stopping it within six turns would be the same as bringing a mile-a-minute auto to a dead stop in 2.73 feet.

"It is called a magnetic brake but magnetism plays no part in its stopping operation. A cork shoe and friction does the trick," according to Mr Hall. "Magnetism releases it, once the need for braking is removed The motor is braked at all times, except when current is applied."

Another feature of this brake, from a manufacturing viewpoint, is that there are 15 parts, compared to 51 parts in the model previously used for this purpose

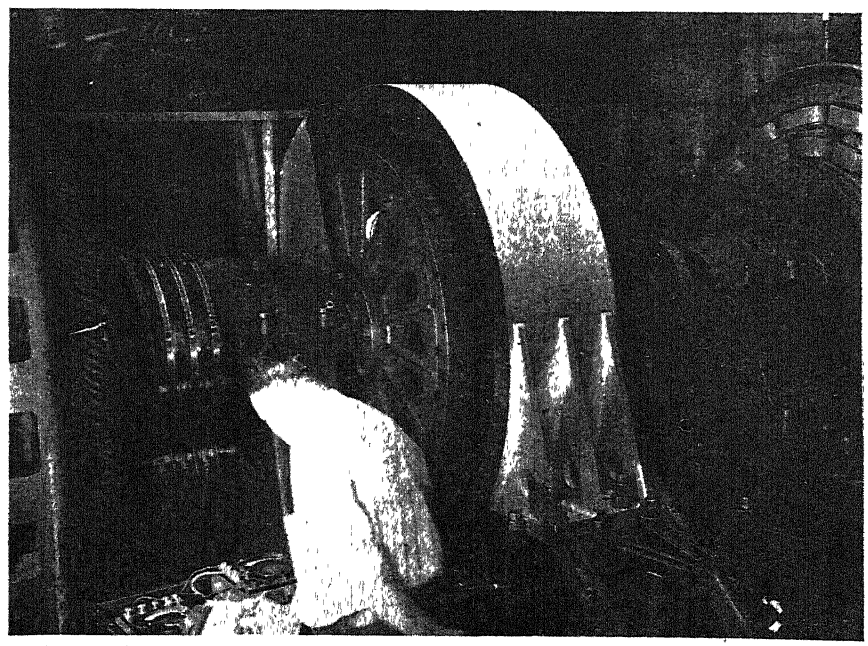
SPEED REDUCTION

Accomplished for Ship Drives By New Electrical Device

REDUCTION of speed between modern high-speed prime movers and drive shafts for mechanical applications where gears and coupling combined are ordinarily necessary, is accomplished by a new electrical device recently announced by the Ridgway Division of Elliott Company, manufacturers of power and process equipment. This is an electric drive which maintains a substantially constant speed ratio between driving and driven members of ship propulsion equipment. The new unit also provides some power for auxiliary service loads through slip ring take-off circuits and can be used as a source of electrical power for operation of cargo handling and similar functions when disengaged from its primary job of speed reduction and torque multiplication.

Three main elements, concentrically mounted, comprise the drive. These are (1) an engine element which is bolted to the prime mover shaft, (2) a shaft element which is coupled to the driven shaft, and (3) a stationary element.

The engine element, which is essentially a synchronous generator rotor with poles selected for the desired



Part of the shaft member of a Bowes ship drive is visible here. See text above

Spectrograms made by the light radiated from a bar of ultra-pure iron as it glows under the heat of an electric arc (above), are compared (right) with wavelength "portraits" of other metals for checking quality

speed ratio, is permanently attached to the shaft of the prime mover and revolves at the normal engine speed.

The shaft element consists of a rotating spider on which two armatures are concentrically mounted in relation to the engine element.

The inner armature, together with the engine element, form a generator. Its winding not only generates electrical energy but also transmits torque to the driven shaft of the unit.

The outer armature makes use of the field of the third or stationary element to operate as a motor, converting electrical energy into mechanical energy for turning the driven shaft.

If the shaft element is held stationary the inner parts of the Bowes Drive, as the device is known, behave like an ordinary synchronous generator and electrical energy can be taken continuously from the drive. This is particularly advantageous on a ship propulsion system where large amounts of power are frequently required while the vessel is in port. In normal operation, of course, the shaft element rotates at the speed desired for the driven shaft. The relative speed between the engine field element and the shaft element adjacent to it results in the generation of electrical power. The reaction torque which, in a normal generator, would be absorbed by the frame supports, is available to turn the shaft element.

The immediate application of the Bowes Drive is expected to be for ship propulsion where it will be used to reduce (by wholly electrical means) the speed of modern prime movers to the lower speeds required for the most efficient operation of propellers.

PUREST IRON

Serves as Yardstick For War Metals

In the Pittsburgh area, where steel output is measured in millions of tons annually, scientists are now engaged in "mass production" of ultra-pure iron— at the rate of only 1000 pounds a year

Made in "radio wave" furnaces at the East Pittsburgh Works of the Westinghouse Electric and Manufacturing Company, the special iron enables United Nations war plants to keep close check on the metals going into guns, planes, tanks, and ships.

The iron contains only about one ounce of impurities in the 1000 pounds produced each year and provides a yardstick against which the composition of steel, aluminum, magnesium, and other metals vital to the war effort may be quickly and accurately measured.

A process developed by Dr. T. D Yensen, manager of the Magnetic De-

partment of the Westinghouse Research Laboratories, made possible "mass production" of this chemically untainted iron. Formed into rods about the size of a lead pencil, the 99.999 percent pure iron is used in steel mills, war plants, and laboratories in all parts of the anti-Axis world. The rods are put in a metal-analyzing spectrograph, which heats the iron with an electric arc This causes the iron to radiate light rays which print a wavelength picture, a series of vertical lines, on photographic film.

These wavelength pictures of the pure iron are then compared with similar pictures of the metal being tested, enabling investigators to determine the composition of the latter swiftly and accurately. Iron is used as a standard because its spectrographic picture contains a large number of lines, which make it easy to identify the test metal's components.

Until Dr. Yensen perfected his process in the laboratory, the best standard obtainable was iron 99.9 percent pure—one part in every thousand was some foreign material which added confusing lines to the wavelength picture. Now only one part in every ten thousand is not iron.

SOFTER ICE

Produced With Aid Of Carbon Dioxide

Carbon dioxide has solved one problem of ice manufacture, eliminating brittleness in ice blocks and making it possible to increase production as much as 35 percent, according to a report to the American Chemical Society.

Use of low temperatures to freeze water naturally increases the capacity of an ice plant, but ice frozen so quickly tends to shatter, says Dr. Philip W. West of the Coates Chemical Laboratories, Louisiana State University. But carbonation of the water, he reports, makes "softer" ice, and prevents cracking or shattering, even in cases where other softening and anti-crack compounds failed

The process is economical, and in some cases carbonation has enabled as high as a 35 percent increase in production without addition to existing plant facilities.

Ice blocks may shatter from both mechanical and chemical causes The mechanical faults usually can be readily eliminated. One main chemical cause is strains of impurities such as calcium carbonate caught in the quick-freezing ice Softeners are used to counteract this, but use of carbon dioxide appears even more effective.

An even greater problem in ice manufacture is opaqueness, resulting from high concentrations of total dissolved solids in the water, particularly the bicarbonates of calcium, magnesium, and iron, Dr. West points out. Among recent advances in water treatment are demineralized filters which can be used to remove minerals from waters which could not be treated by older methods

"Filters of this type now make available to the ice industry hundreds of waters which previously could not be used," Dr. West says.

The ice industry in this country consists of almost 4000 individual plants, annually producing over 34,000,000 tons of ice, 91 percent of it from fresh water

PLANT CLEANING

Speeded by "Blowing Down" With Compressed Air

Preaching cleanliness might be expected from a laundry The way in which one such concern practices it in

An air hose used for plant cleaning

keeping its own plant clean suggests a method other industries might adopt in their plant cleaning programs.

A problem peculiar to laundries is clinging lint and ravelings which float away from cotton articles to the tops of overhead pipes, underneath machinery, close to electric motors from which a spark might find ready tinder, and in hard-to-get-at corners. In different

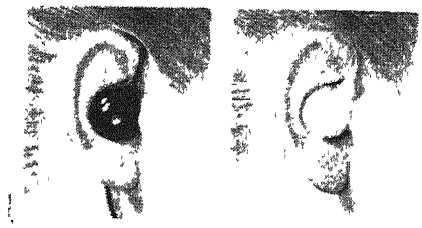
GONE IS THE OLD BLACK BUTTON AND CORD

Hard-of-Hearing Acclaim Zenith's New "Look of Youth"!

NEW NEUTRAL-COLOR EARPHONE AND CORD

Less Noticeable than Eyeglasses!

OFF WITH THE OLD



ON WITH THE NEW

(Standard Equipment .. No Extra Cost)

ONCE more, the public response to another great Zenith hearing aid advancement has far exceeded even our most glowing forecasts!

By their nationwide acclaim, America's hard-of-hearing have told us this new Zenith Neutral-Color ensemble is what they have been hoping and waiting for.

And no wonder! Note how it makes the earphone and cord even less noticeable than eyeglasses . . . brings a new smartness and "look of youth" which now enables the most sensitive-minded person to wear a hearing aid with poise and confidence.

The new plastic earphone complements any complexion. It is extra-light in weight, comfortable, long-wearing. The slender, translucent plastic cord, too, looks well with any apparel. It is perspiration-proof . . kink-proof . . will not fray . and gives less clothing or friction noise than any fabric-covered cord.

Today—see for yourself how this new Zenith ensemble does for the hearing aid what modern smart styling did for eyeglasses! Find out about Zenith's *personal adjustment* principle . . . how the exclusive external Tone Control enables you to fit the Zenith yourself—to begin at once a lifetime of better hearing.

Visit your Zenith-franchised dispenser for a *Free* demonstration. No obligation. Or mail coupon below for Free, complete, detailed description and name of the Zenith dispenser near you.

• • •

Also available — the new Bone Conduction and Bone-Air Zeniths for those very few whose physicians recommend these types of instruments. Each only $10 more. complete

BY THE MAKERS OF ZENITH "LONG DISTANCE" RADIO

RADIONIC PRODUCTS EXCLUSIVELY— WORLD'S LEADING MANUFACTURER

CANADIANS! The Zenith Radionic Hearing Aid with *Neutral-Color Earphone and Cord* is now available in Canada—*direct by mail only*—at $40 (Canadian currency). No extra charge for shipping, duties or taxes! Write Dept. SA-10, Zenith Radio Corporation of Canada, Ltd., Guaranty Trust Building, Windsor, Ontario

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NEW ZENITH RADIONIC HEARING AID

MODEL A-2-A

$40 COMPLETE

Why Its Fine Quality Costs You So Little

Like your watch, this hearing aid is a product of precision mass production. If only a few were produced, they would cost many times as much, be far less accurate. But Zenith precision mass production brings you at $40 an *even finer* hearing aid than its original $50,000 hand-made model . . just as Zenith lowered the price of a $200 radio to $29 and made it an *even finer* instrument. Remember—Zenith leads the world in precision mass production of Radionic products exclusively

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Please send me your Free Booklet on the new Zenith Radionic Hearing Aid, together with name of nearest dispenser

Name .....

Address .....

City ..... *State* .....

☐ Physicians check here for special literature.

types of plants it could be dust or soot or some other accumulation than lint

The Davis Laundry and Cleaning Company, one of Cleveland's oldest and largest family laundries, rids its plant of lint by "blowing down" its building with compressed air every week-end, when workers are off. The master mechanic claims air dislodges the dirt better and quicker than any other known method.

A maintenance man goes through the plant from stem to stern, including ceilings, walls, and floors, blowing the fluff before him. Overhead pipes and ceiling areas are easily reached simply by attaching the air hose to a pole with clamps. Drying tumblers, where the lint is especially heavy, are cleaned by blowing out the lint. Compressed air reaches all other critical spots in the laundry, too.

Conveniently located air outlets facilitate the "blowing down" operation. The compressed air is supplied by the same compressor that delivers the power that operates the laundry's automatic ironing machines and other equipment. A pressure of approximately 75 pounds is maintained. The once-a-week "blow down" not only helps to keep the plant clean and prevent dusty lint from coming down on clean clothes but, equally important, it reduces a fire hazard.

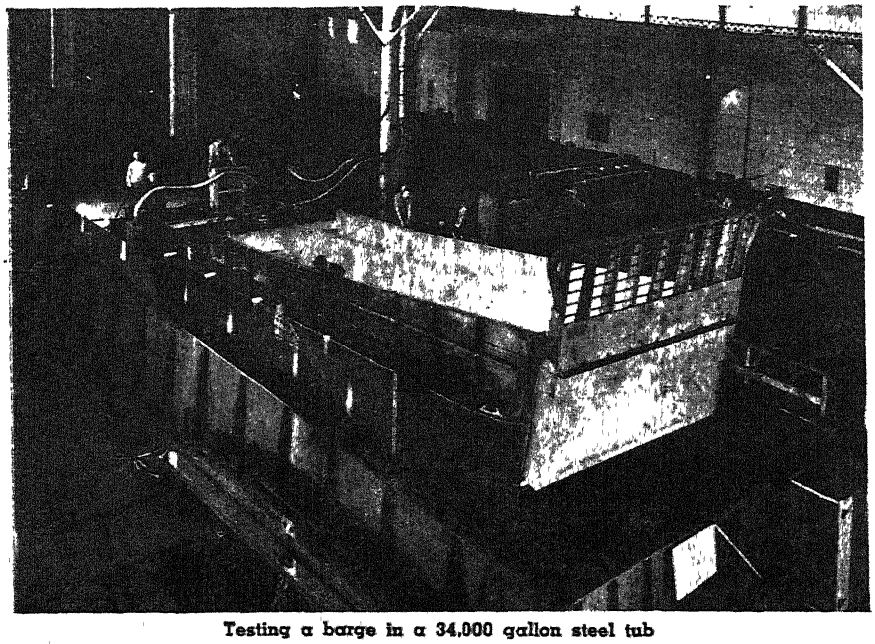
34,000 GALLON TUB

Used for Tests of Landing Craft

INVASION landing craft, produced in the Ohio corn belt at a dry-land shipyard miles from the sea, are "launched" in the only man-made "inland ocean" of its kind—a 34,000-gallon steel tub.

The all-welded, 50-foot barges designed for landing medium tanks, bulldozers, guns, trucks, and personnel are built upside down on an assembly line of the Warren City Manufacturing Company and then inverted for final fabrication and installation of Diesel engines.

From the final fabricating jig each barge is lifted into the "ocean" test tank a few yards from the end of the assembly line Steel cables are attached to keep the craft from leaping out of the tub, and a worker standing at the control panel and wheel on the pilot deck gradually speeds up the Diesels until the water whips into white, boiling foam. The barge strains at its cables, riding up and down on the waves it creates itself. Each test lasts two hours.



Testing a barge in a 34,000 gallon steel tub

INDUSTRIAL DOLL-HOUSES

Permit Design Engineers to Plan Efficient Plants

TOMORROW's industrial plants—geared to peace, not to war—will first rise as "industrial doll-houses" in the workshops of plant planning and layout engineers.

Complete construction in miniature to give engineers a three-dimensional preview of a plant's efficiency already is standard procedure for planning engineers of the Westinghouse Electric and Manufacturing Company Now tiny figures of men and machines, carefully carved from wood, are moved around in "doll-house" factories. After the war, metal figures, molded for permanency, will form a "bank" from which the engineers may draw to construct their little industrial domains.

On "deposit" in these banks will be a score or more of each type of machine used in the electrical manufacturing industry. As new machines are developed, new molds will be made and new miniatures cast to keep the bank up to date.

When companies seek new manufacturing facilities, the engineers will move with speed and accuracy and the time and cost of planning factories will be reduced.

From two-dimensional drawings, skilled woodworkers will construct a "doll-house" factory along the general lines needed. In it they will put traveling cranes, roller tracks—every piece of equipment that is part of a modern

Even routes for roller conveyors are determined in miniature by engineers using "industrial doll-houses"

plant Then, from the "bank," they will select the number and type of machines needed for the required amount of production. These will be placed in the miniature plant, moved about like men on a chessboard. Because the figures are accurately scaled, engineers can tell in advance how much floor space each machine will take in the completed factory, how much aisle room there will be, and so on

Given this preview of the factory's workings, engineers may change the design of the miniature plant better to meet its specific needs. When they are through, nothing will have been left to guesswork. Construction men will expand the "doll-house" a thousandfold and a new industrial process will have been efficiently served.

Previously, two-dimensional drawings provided engineers with their preconstruction view of a plant, but even the keen minds of engineers and factory planners couldn't translate mechanical drawings into completely efficient factory units every time. Now and again the completed factory had gremlins—not numerous, but formidable and sometimes costly.

Pre-construction in miniature is not the only field where the "doll-houses" have proved invaluable. Rearrangement of plants already in use now is accomplished more efficiently by mapping out with the tiny models Space and facilities are better utilized.

WIRE INSULATION

Developed by Special Formulation of Buna S

NUBUN, a synthetic rubber latex insulation for power, lighting, and communication cable has been developed by United States Rubber Company The new insulation is a result of wartime developments in rubber technology and will permit the design of new types of wire and cable with improved electrical and physical characteristics.

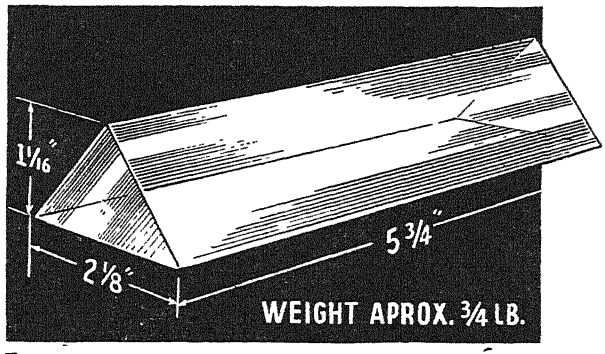
Made by the latex continuous dip method, Nubun will have great advantages over ordinary wire insulations where replacement and space are important factors. Fire alarm, wire and cable police communication systems, as well as other highly essential telephonic systems, will be more easily

SENSATIONAL WAR BARGAINS *in* LENSES & PRISMS

All Items Finely Ground and Polished but Edges Slightly Chipped or Other Slight Imperfections which We Guarantee Will Not Interfere with their Use. All Lenses neatly packed and marked for Diameter and Focal Length.

OUR POLICY on WAR SURPLUS

1 We are cooperating to move surpluses while the war is on.
2. Our customers receive full benefits of all savings effected through our purchases of war supplies. We do not hold merchandise for high future prices.
3 We are making an effort to bring our items to the attention of all Schools, Colleges, Amateurs.



TANK PRISMS

In order that the tank driver shall not get shot in the face, two of these Silvered Prisms are used to make a periscope (without magnification). We have secured a number of these that are very slightly chipped, making possible their sale at a very low price. They are 90-45-45 degree prisms of huge size — 5¾" long, 2⅛" wide, finely ground and polished.

Other uses for these Prisms: Experimental Optics, Optical Instruments and Gadgets, as unique gift item, unusual paper weight, desk name plate, etc. Normally these Prisms would retail from about $24 to $30 each.

Stock #3004-S . . . SILVERED TANK PRISM — Price $2.00 each Postpaid. Free Booklet on Prisms incl.

Stock #3005-S . . . PLAIN TANK PRISM — Price $2.00 each Postpaid. This one is excellent for projecting all the colors of the spectrum — a beautiful sight. Free Booklet on Prisms incl.
FOUR PRISMS — Special — $7.00 Postpaid . . . This is the most sensational bargain we have ever been able to offer.

100 Gold Gummed Letters . . . 5¢ Will make a Silvered Tank Prism into an expensive looking desk name plate in a few minutes of easy work. A swell gift item.

ROOF (Amici) PRISMS #5BS . . $1.50 Postpaid
A few chipped but most were rejected because roof angle was off trifle more than 2 seconds. Excellent for most uses except for instruments of over 3 power. A. T. M.-ADVANCED gives directions on how to correct the roof for use in higher power telescopes

PORRO ABBE PRISMS #3006-S 25¢ each Postpaid
Size 9 mm. by 17 mm. . . . another war bargain. Normal prices would be 10 to 20 times above quotation.

RIFLESCOPE LENSES Set #2000-S $11.00 Postpaid
5 achromats matched by manufacturer. Cemented, ready for construction of fine 3½ power 'scope which would retail up to $50.00 A rare opportunity! Full instructions included.

LENS SET 120-S "The Experimenter's Dream" 60 lenses with 50-page illustrated booklet "FUN WITH CHIPPED EDGE LENSES" — $10.00 Postpaid.
The variety of lenses in this set will enable you to conduct countless experiments and build many optical gadgets.

OUR SECOND ANNUAL GADGET AND OPTICAL CONTEST NOW ON FREE DETAILS FURNISHED WITH ALL PURCHASES

REDUCING LENS SET #1004-S . $1.20 Postpaid
Contains a 2½" diameter and 1¾" diameter reducing lens of different powers.

50-PAGE ILLUSTRATED IDEA BOOKLET $1.00 Postpaid
Describes wide variety of uses for our lenses and contains much information especially designed for beginners in optics.

SCHOOLS & COLLEGES — Get on our mailing list. Keep regularly posted about our Optical Bargains. Send name, address to our Educational Dept.

WAR SURPLUS ACHROMATIC LENSES

Stock No.	Dia. in Mms.	Focal Length	Comments	Price
6016-S	*12	80 mm.	Uncemented	30¢
6017-S	*12	80 mm.	Cemented	50¢
6018-S	*15	41 mm.	Uncemented	40¢
6019-S	*15	41 mm.	Cemented	60¢
6020-S	*18	49 mm.	Uncemented	50¢
6021-S	*18	49 mm.	Cemented	60¢
6022-S	*25	95 mm.	Uncemented	50¢
6024-S	*25	11 inches	Uncemented	60¢
6025-S	*25	11 inches	Cemented	75¢
6028-S	*30	64 mm.	Uncemented	70¢
6029-S	*35	60 mm.	Uncemented	70¢
6030-S	*36	171 mm.	Uncemented	70¢
6032-S	*36	178 mm.	Uncemented	70¢
6033-S	*37	51 mm.	Uncemented	70¢
6034-S	38	178 mm.	Uncemented	70¢
6037-S	41	57 mm.	Uncemented	70¢
6038-S	43	57 mm.	Uncemented	70¢
6044-S	11.5	24.5 mm.	Cemented	$1.50
6045-S	13.5	48 mm.	Cemented	$1.50
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replaced and serviced and will have greater resistance to destructive forces which cause circuit troubles with the use of this type of wire.

Qualities claimed for Nubun insulation include flexibility, impermeability to water, laminated construction, and perfect centering of the conductor to produce an insulated wire of maximum conductivity and minimum diameter. The synthetic insulation is said to be exceptionally homogeneous following vulcanization and has high electrical characteristics such as di-electric strength and insulation resistance. The special synthetic rubber compound is low in specific conductive capacity, has good aging qualities because of the presence of special anti-oxidants, and will resist severe wear because, by the nature of the latex process, the rubber particles are not distorted or broken down by milling.

Nubun insulation is made from a special modification of buna S synthetic rubber.

ENGINE OPERATION

Improved if Four Steps are Followed

FOUR STEPS to avoid dangers resulting from formation of hot engine sludge in motor vehicle engines were recently recommended to an SAE National Transportation and Maintenance Meeting by H. C Mougey, of Research Laboratories Division, General Motors Corporation

They were. application of oil filters, adequate temperature control, frequent crankcase draining, and use of high quality or heavy duty oils

Filters help to remove the sludge as rapidly as it forms, Mr. Mougey reported. Temperature control prevents excessive heat from causing oil oxidation and sludge formation, without permitting engine temperatures to get so low as to form low-heat sludge. Crankcases should be drained with sufficient frequency to prevent sludge accumulations from becoming too large, Mr. Mougey explained, adding that draining periods must be determined by use rather than by time or mileage.

Heavy duty oils were described as having a good resistance to oxidation and as discouraging formation of acid and sludge. Mr. Mougey added that when these oils are drained, they carry away much of the sludge and leave a comparatively clean engine

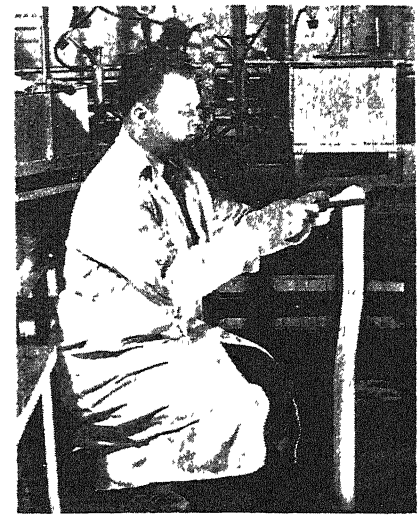
FOAM PLASTICS

Have Possibilities in the Insulation Field

A NEW type of plastics foam, which is lighter than rockwool, glass, or cork and lower in heat conductivity than any of the three, was announced recently by General Electric. Its present uses are secret but after the war it promises to have many peace-time applications, especially where insulation is required.

An outstanding characteristic of this new development in the company's plastics laboratory is that the material is self-raising and self-curing. In other words, the mixture, which resembles molasses, will begin to foam or expand within two to five minutes after the mixing stops and cures without the application of heat or any other element.

"It just grows all by itself," Dr. J J Pyle, director of the laboratory, explained. "It will foam into 30 times its own size; that is, a quart can of the mixture will expand sufficiently to fill a seven- to eight-gallon receptacle in about 10 minutes. What little heat is



Known as foam plastics, a new composition grows at an inch a second

needed is self-generated by the mixture itself.

"This type of foamed plastic weighs less than two pounds per cubic foot and is particularly good for insulation. Another type, of greater mechanical strength but weighing seven to eight pounds per cubic foot, has also been developed. This will also have many peace-time uses, we believe," Dr Pyle said

ORE THAWING

Solves a Winter Problem of the Steel Industry

FORESHADOWING a process likely to be widely adopted by steel makers, an ore car thawing plant constructed by Rust Furnace Company, for Carnegie Illinois Steel Corporation, has successfully completed its tests. Purpose of the plant is to overcome the winter-time condition in which ore from the Lakes becomes soaked with moisture and freezes in the cars so that it will not run out when dumped.

This condition has been met by crude and inefficient methods in the past which have included holding gas jets against the cars, building wood fires under them, and placing them in sheds under steam for hours—all wasteful of time and labor, and incidentally not contributing to the life of the cars

Accordingly, an automatically operated plant for the specific purpose of surface thawing ore cars, so as to permit the ore to fall free of the car when unloaded by a dumper, was planned. This plant consists of a building with a capacity of two 90-ton ore cars on a track which runs through it An additional track is provided for an

electrically operated pusher locomotive. Housed on a second floor are combustion units for producing hot gas for recirculation and application against the cars.

The arrangement includes a thaw chamber, where the cars stand; two double chamber furnaces with rated capacity of 10,000,000 Btu per hour each; two fuel-oil-fired burners, combustion air fan, fuel supply line, steam supply line for fuel atomizing, and motor-driven air recirculating fan, together with the necessary ducts, passages, and controls.

The thawing operation consists of circulating air and gases from the combustion chamber through a closed air circuit, comprising the thaw chamber, furnace, fan, and interconnecting ducts, the air being alternately heated and cooled in its passage.

In operation, two loaded cars are positioned in the thaw chamber and the doors are closed; whereupon the furnaces and air recirculating fans are put into operation. An adjustable cycle timer regulates the thawing cycle in two periods of approximately ten minutes flash heating in excess of 500 degrees, Fahrenheit, and a cutback to between 200 and 250 degrees for five to 10 minutes of base heating or soaking.

SILVER PLATING ALUMINUMS

Has Advantages in Electrical and Heat-Transfer Field

SILVER may now be deposited electrolytically onto aluminum or aluminum alloys by means of a simple method, known as the Preplate Process, a development of the Technical Processes Division of Colonial Alloys Company.

Silver deposits of considerable thickness can go directly onto the aluminum surfaces, or can follow a copper, nickel, zinc, or cadmium deposition.

The aluminum is thoroughly cleaned as prescribed, passivated, immersed in "preplate solution" for a few seconds, and then electroplated in the usual manner, using the regular equipment found in all plating shops.

Because of its high rate of electrical conductivity, silver plating onto light weight aluminums opens vast possibilities in the electrical equipment, appliance, transportation, and communications fields. Rated high on the scale in conductivity and transfer, silver on aluminums may be considered favorably in many heat-transfer applications.

As a protective and decorative application, silver plating on the brasses and white metals has been known for a long time. Silver plating on light weight aluminums should now find sizeable usage in this field.

POST-WAR ENGINEERING

Can Provide More Goods at Less Cost

ENGINEERS not only must win the war but also must lead the post-war effort, according to Everett S. Lee, head of the General Electric General Engineering Laboratory.

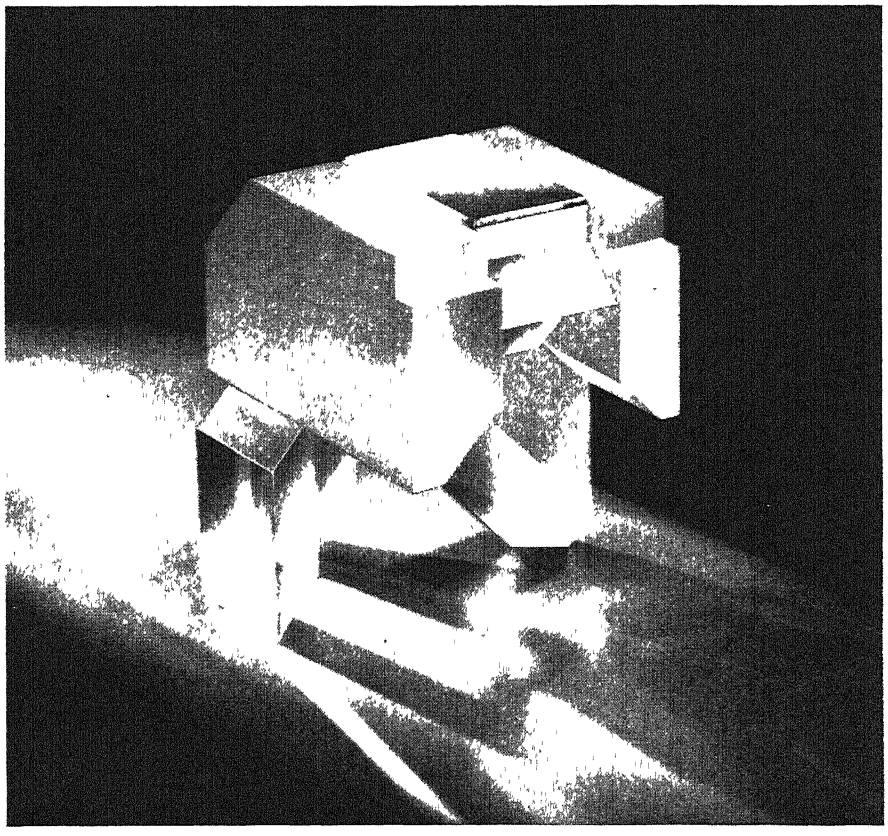
"In post-war planning," Mr. Lee says, "the engineer must take his part, for engineers and scientists continue to produce even though there may be defeatism all about. Witness the years 1929 to 1939, a period when the spirit of courage to go forward was too lacking, much to our shame as we look back upon it now. And yet in that period came streamlined trains, television, transoceanic passenger air service, synthetic rubber, fluorescent lighting, colored home movies, new plywoods stronger than steel, many new plastics and resins, polarized glass, glass building blocks, fiber glass for insulation and textiles, synthetic hosiery replacing silk, synthetic vitamins, sulfanilamide and sulfapyridine."

There was no lack in those years in engineering and scientific contributions, Mr. Lee points out, in emphasizing that there will be no lack in the years to come.

"But," he says, "the planning to go from an emergency to an after-emergency period must be such that there are no rapid changes, for it is rapid change which produces surges. Planning for a smooth transition, the replacement of expenditures for arms for war by expenditures for goods for peace, thus becomes a necessity."

Mr. Lee cites the accomplishments of engineers in the field of electrical measurements as evidence that "this transition is not an impossibility."

"There are similar stories," he continues, "in the advances in the auto-



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This is the same care and these the same skills that are also producing the fine optical instruments used in the furtherance of our war effort. Tomorrow, many of those instruments will be available to help build better lawnmowers . . . razor blades . . . automobiles . . . vacuum cleaners, etc. . . . to hasten progress in scientific research, medicine, education.

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WELDING PROCESS

Salvages Castings,

Prepares Them for Metallizing

DEVELOPED primarily to solve problems of reclaiming defective aluminum castings, and used with equal success in salvaging bronze, grey iron, malleable, and steel castings, the new Nervous Weld Process is also being used for building up surfaces for press fits, repair of cracked housings and motor blocks, as well as for preparation of surfaces for metallizing

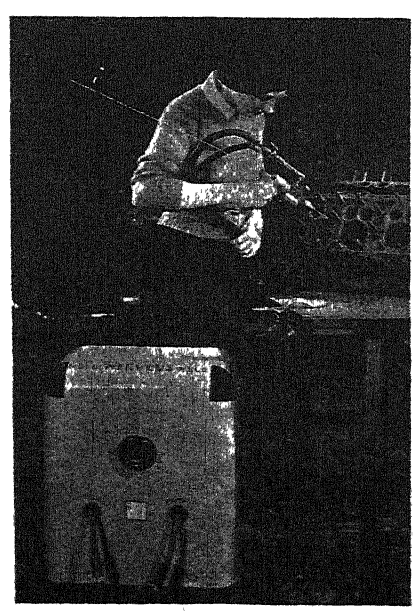
The word "Nervous" is applied to this process to dramatize the vibrating motion imparted to the welding rod by the air operated pistol. This pistol requires approximately 60 pounds of air pressure at four to five cubic feet per minute and is used in connection with a Mogul Nervous Weld machine.

The welding rod passes through the pistol and extends beyond it, feed of the rod being accomplished by means of the pistol trigger. In the bottom of the head of the pistol is a vibrating piston which causes the welding rod to make and break the arc at the working surface, as well as to peen and forge the resulting particles of deposited material. There is no lumping of the welded material since small globules of material are deposited in succession and small particles are welded and forged to small particles. Thus a dense weld may be built up with no great degree of heat.

The same air which actuates the piston of the welding pistol also passes through holes in the nozzle of the pistol, surrounding the electrode with an air envelope which has a cooling effect at the point of weld.

One of the demonstrated advantages of the Nervous Weld Process is that it doesn't create stresses and distortion in the surface being built up. The temperature never rises above 125 degrees, Fahrenheit, yet the deposited material is so dense at the point of fusion that there is no apparent line of demarcation

The main value of this rapid method of welding is for filling in surface imperfections which have no effect on the structural strength of the article being repaired. This is of particular importance when surfaces are to be prepared for plating or metallizing.



By the Nervous Weld Process, metal is peened as it is deposited in place

RELATIVE POROSITY

Shown by Newly

Designed Vacuum Device

RELATIVE porosities of materials can be determined by an apparatus devised by Stuart H Hahn and Robert H Judson of The B. F. Goodrich Company. The porosity is tested by the degree of vacuum in a chamber which is an important part of the apparatus.

Chief object of the invention is to provide a mechanism for determining the relative porosities of various materials by drawing air or gasses through the material and indicating the rate of flow. The apparatus was originally developed for testing the porosity of various types of sponge rubber, but it has many other applications, the company believes.

So small and compact that it can be easily lifted and transported with one hand, the apparatus consists of a vacuum chamber placed in contact with the material to be tested, a constant-speed, power-driven fan for evacuating air from the vacuum chamber, an outlet port for emitting the air, and a pressure gage to measure and indicate the degree of partial vacuum in the chamber. An arm connected with the manually operated switch which starts and stops the fan holds the measuring indicator in position when the switch is turned off

MOTOR-CAR GAS

Use and Quality Depends

On a Number of Factors

EXPERT opinion expects gasoline demand in the immediate post-war period to be at least 75 percent of recent pre-war requirements, largely because of the decrease in number of serviceable cars which will be available to consumers, according to a survey reported by Alberta H. Adams and B. H. Weil of Gulf Research and Development Company in *Chemical and Engineering News*. Most authorities expect demand to rise to a new high in the second phase of the post-war period.

"Consensus among automotive and petroleum experts indicates that some 20,000,000 of the nation's pre-war total of nearly 30,000,000 cars will remain in operating condition at the war's end, maintaining, with the help of some military consumption and increased commercial and farm use, a volumetric market for gasoline of at least 75 percent of the pre-war level," the survey states.

"A rapid recovery to or above normal

pre-war use is expected to follow as new tires and cars come into production The immediate post-war cars will probably be the 1942 models, with changes in automobile design expected to come slowly. Hundred-octane automotive fuels are not expected to be required for some years, if ever."

In planning for the post-war period the petroleum industry must be cognizant of the many factors that influence the volume of probable post-war markets for its bulk products, especially gasoline, it is pointed out.

"Probably most important is the number of cars still unscrapped and operating on at least four usable tires at the end of the war. Naturally, the duration of the war is certain to have a large effect on this number, and estimates are as varied as those on the date of the war's termination. A conservative guess might place this number at approximately 20,000,000, or about 70 percent of those operating when the war began.

"The next factor of importance is the determination of how soon more cars can and will be put in operation after the war. Easiest and quickest to put on the road are those needing only reconditioning and new tires. If the rubber is available, as it now appears almost certain to be, molding capacity should be sufficient to put all operable cars back on the road in less than a year, assuming that there will be skilled labor available to operate the machinery.

"The problem of getting 'new' cars on the road is more serious. It is believed that the first post-war cars will be the same models as the last pre-war cars, and that less than half a normal year's production can come off the assembly line in the first post-war year! This means that it will take perhaps two years to furnish replacements for cars lost to service during the war years and that production of the true 'post-war' car of a new design cannot begin much before that time.

"Most authorities predict that changes in the post-war cars will be gradual as they have been in the past. Of particular interest to the petroleum industry are the widespread beliefs that post-war cars will be more economical in their use of fuels, because of some application of lighter-weight metals, greater use of automatic transmissions, and the probable use of gasolines of somewhat higher octane ratings.

"It seems possible that 100-octane fuels may eventually find use, at least as the premium-grade fuel, although this may not be very soon after the armistice. House-brand gasolines are not expected to be higher than 80-octane in the immediate post-war period, and either one or two grades of premium fuels will probably be put on the market, with octane ratings perhaps somewhere between 85 and 90

"Auxiliary automotive markets will also affect the market outlook, inasmuch as military consumption should drop and commercial, farm, and civilian aviation consumption rise. These trends are likely to be sharp during the immediate post-war period and more gradual thereafter, except for aviation, which may rise sharply for some time.

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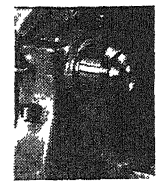

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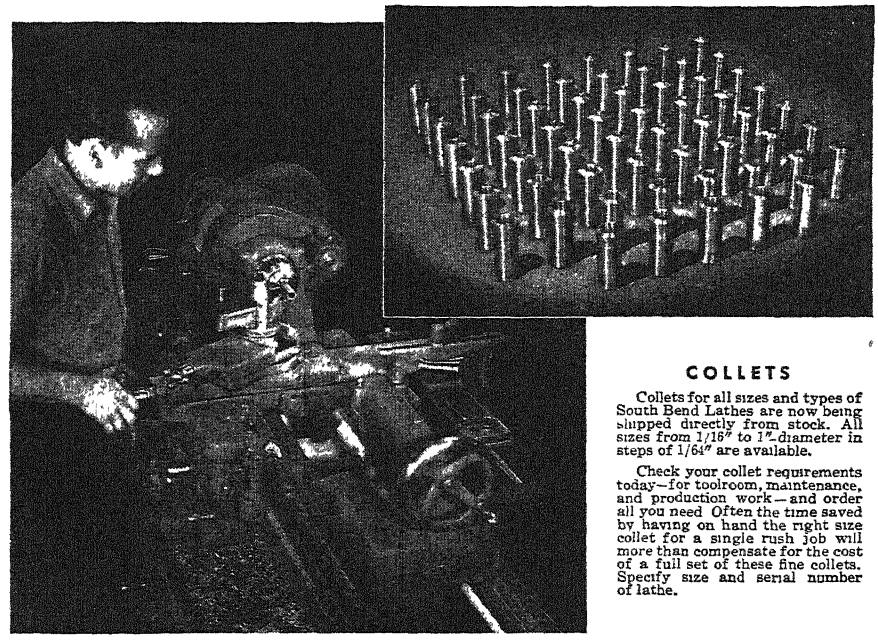

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"In general, prospects for gasoline markets are not particularly dark, even in the immediate post-war period; in the subsequent period of anticipated prosperity, the outlook seems to be good indeed. In the former period there seems to be little chance for a widespread demand for 100-octane gasoline other than for aviation use, although lessened demands for the latter purpose probably will make a large volume of high-octane stocks available. In the latter period, however, it may eventually find an automotive market."

BATTERY SEPARATORS

Made of Rubber, Permit Dry Shipment

A MICROPOROUS, wafer-thin rubber is now replacing wood in the manufacture of storage batteries. Its use as a plate separator makes possible for the first time the shipment of these batteries to all battlefronts in a fully charged condition but without the acid and water heretofore necessary to insure the electrical charge as well as the life of the battery.

This material, developed by scientists of the United States Rubber Company, has millions of tiny cells per square inch. Unlike wood it will not buckle if the protecting acid and water mixture becomes low or completely expended.

Buckling of wood separators which this material replaces was considered by the battery industry to be the prime reason for battery failure. The use of rubber completely eliminates this possibility, for these separators will outlast wood at the ratio of five to one, in acid strength of 1.25 specific gravity.

This compound has higher resistance to abrasion and chemical reaction than wood. The separators are designed to outlast the life of the battery.

After the battery has been completely charged, the acid mixture is taken out of the battery. The plates and separators are then removed and completely dried. After all moisture has been eliminated, the unit is replaced in its regular position. The battery is again sealed and made ready for shipment

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replaced and serviced and with new. Batteries thus treated retain 75 percent of the original charge after being placed in storage for more than a one-year period.

This method of charging, drying, and shipping makes possible the immediate use of the battery after distilled water and acid have been added.

SURFACE CONDITIONING

Speeded by Use of Special Power-Driven Brush

POWER brushing, by the use of a portable-tool-driven, steel-bristled cup-shaped brush, is reported to make possible the method by which the acres of steel surfaces on the seven-mile-long San Francisco-Oakland Bay Bridge is properly conditioned for the application of protective paint, a job that takes all the time of 15 to 20 men, working year in and year out.

This power-brushing unit, with which each man is equipped, removes fog- and spray-deposited salt, also loose scale and paint, from the steel surfaces prior to repainting. This method is at least ten times faster than hand surface preparation, according to The Osborn Manufacturing Company.

The brush itself is approximately 3¼ inches in diameter, heavily filled with coarse, .020 S.A wire, the wires extending 15/16-inch out of the cup. Operated in and driven by a portable hand tool, the brush spins at 4200 revolutions per minute Rotating at this speed, with its coarse wires in contact with the steel surface, the unit speedily brushes away scale and leaves sound, clean metal for reception of paint.

Power brushing conditions surface

TOBACCO SMOKE

Used to Test Filtering Mediums

TREMENDOUS clouds of tobacco smoke puffed out by an automatic pipe smoker are now being used to test the filtering efficiency of special felt used in making respirators for industrial workers, according to the American Optical Company.

The tobacco smoke, employed because

An automatic pipe smoker being used to check the efficiency of filters

of its extremely fine, uniform particles, is first expelled into a small room by a large metal pipe burning tobacco under forced draft. Then the smoke is drawn out of the room and through a strainer fitted with a piece of the felt

Particles of matter remaining in the strained smoke are then measured by a complex scientific device which employs a light beam to illuminate the particles in the air. The concentration of particles is then compared with that of unstrained tobacco smoke to ascertain the filtering efficiency of the felt.

This type of test was described by the optical concern as the speediest and most effective for selecting the best filter material to safeguard the respiratory system of workers exposed to dusts and fumes

ROUGH SURFACING

Desirable Where Positive Lubrication is Required

SEVERAL years ago Ford Motor Company metallurgists introduced a chemical etching process to make porous the surface of various engine parts. This was done after tests proved that steel surfaces can be made so smooth that they actually repel lubricating oil, resulting in rapid wear, excessive heat, scoring, and subsequent failure.

Experience gained before the war has thus helped to improve the wearing qualities and dependability of Ford-built tank and aircraft engines, numerous parts of which are "rough surfaced" by the same method.

"Rough surfacing" is desirable where positive lubrication is required between parts that are held to close tolerances. Various chemicals can be used for the purpose. An acid phosphate, for instance, etches the surface of the aircraft engine fly weight and deposits an iron phosphate. The resulting porous surface retains lubricating oil at all times. Before the treatment was introduced it was not uncommon for aircraft engines to develop excessive vibration or failure due to the scoring of this balancing device.

The depth of the etch is controlled by timing and by maintaining a fixed concentration and acidity of the etching solution at a given temperature.

Many other parts in Ford-built aircraft engines are "rough surfaced."

These include pinion-gear reduction shafts, valve tappets and valve tappet roller pins, push-rod ball sockets, gear pinion reduction shafts, front driven oil pump shafts, and a number of lesser parts.

Steel cylinder sleeves on Ford automobile engines are "rough surfaced" by honing. This means that a light film of oil can be retained on the cylinder walls at all times.

All "surface roughening" is carefully controlled and measured by a profilometer, a device that measures surface smoothness or contour in micro-inches

FARM GLUES

Prove Their Value

For Exterior Use

DEVELOPMENTS in waterproof glues for wood point to the post-war potentialities of plywood for use on the farm Heretofore, the use of plywood has been restricted because it was not strictly waterproof, but the synthetic resin glues such as Lauxite make the use of plywood for farm structures both practicable and economical.

There has been no plywood generally available for farm use during the past months because of war-time requirements However, just previous to the outbreak of the war, recognition of the practicalities of buildings for the farm with exterior type fir plywood had been increasing Farmhouses, grain bins, silos, barns, milk houses, brooders, and feeders built from plywood have proved extremely successful. A particularly bright spot on the post-war farm-rehabilitation horizon is the promise of pre-fabricated production buildings—hog and chicken houses and brooders—built and packaged by lumber dealers, and for sale to farmers for quick assembling

A barn built by the Marine Air Research Corporation incorporates new development in the construction field by using plywood arches and beams as structural parts of the building. The arches of the barn were for a 40-foot span and tests were made to decide whether the roof would carry the load which was designed for 35 pounds per square foot with a safety factor of 2½ pounds. Very few metal connectors were required—only four bolts were used at the ridge.

Once the needs of the armed forces are no longer urgent, exterior type plywood with waterproof glue lines, because of its inherent strength and easy workability, will ably serve the farmer in a number of ways similar to those just described.

ALUMINUM PACKAGING

Offers Numerous Advantages

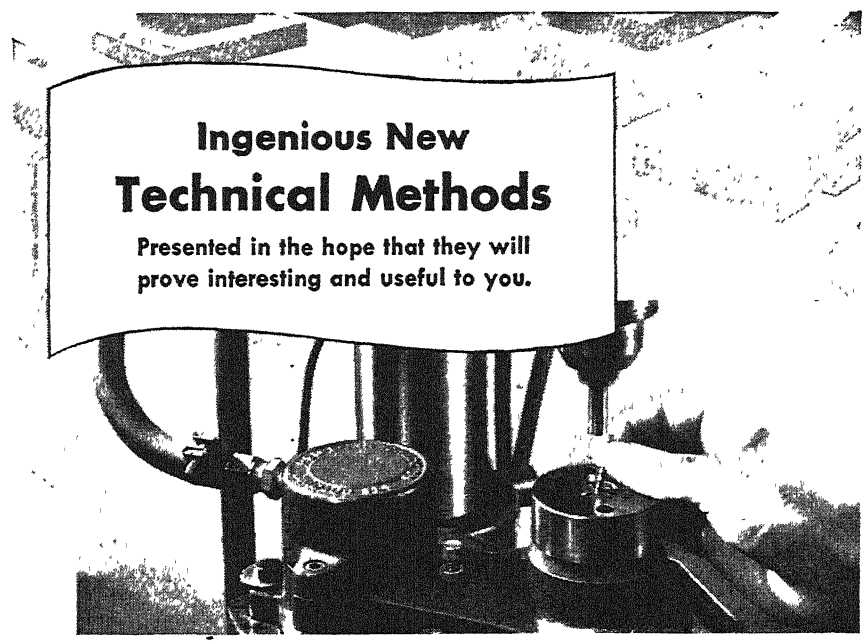
For Protecting Many Products

THAT nebulous cloud surrounding the post-war packaging world has a distinct silver lining—more accurately speaking, an aluminum lining, for this metal, firmly entrenched in a score of pre-war packaging fields, and aided and abetted by valuable wartime experience, is on the list of preferred materials on the drafting boards of tomorrow's package designers

Inherent virtues of aluminum in this field include workability and resistance to moisture, heat, light, and chemical action. It is non-toxic and therefore well adapted for use in the food industry. Also, it is bright and attractive in appearance and lends itself well to modern packaging design Of course, the lightness of the metal is important where shipping costs are a consideration

Uses for aluminum in this interesting field range from chemical containers to tooth-paste tubes. Before the war, cigarettes, photographic film, and yeast cakes were only a few of the products packaged in aluminum foil Your morning milk remained free from dust and germs under a gleaming protective hood of aluminum, while your chewing gum and candy bars stayed fresh longer when wrapped in this same material. Tamper-proof aluminum seals on liquor bottles kept bootleggers at a discreet distance and beer rode to town in sturdy barrels fashioned of aluminum sheet.

Domestically speaking, these uses for aluminum are now but memories, but aluminum packages are very much on the job on the battle front. Invasion troops carry with them, in their ration kits, plastic coated aluminum foil envelopes containing powdered coffee and dehydrated fruit juices You will see a lot of this type of package after the war, not only for powdered coffee and fruit, but for dehydrated fruits of all kinds. Aluminum foil keeps out light and moisture—two valuable traits in many packages—*Aluminum News-Letter.*



Now—Air Operated Collet Chuck Relieves Second Operation Work on Screw Machines

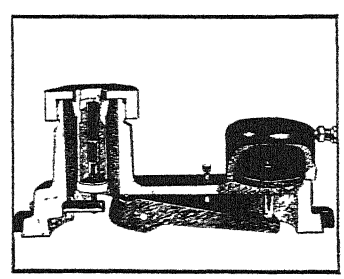
Work formerly requiring automatic or hand screw machines can now be done at much less cost through the combination of this new air chuck and any drill press. The Redmer Air Chuck is a collet air chuck using standard Brown & Sharpe type screw machine collets. The collet remains stationary, the opening and closing controlled by a sleeve action.

By using a collet as the chucking means, slight variations in the diameter of the work as frequently experienced with automatic and hand screw machine products can be permitted without sacrificing accuracy or concentricity. Thus accomplishing an important saving in time and cost.

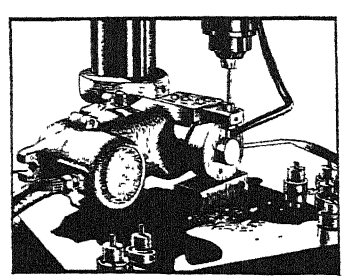
The air chuck is an ideal tool for holding parts for drilling, milling, slotting, burring, chamfering, boring, counterboring, tapping, threading, reaming and other work where the machine operation should be concentric with the chucking surface. It is adaptable to many different jobs merely by changing collet and stop. This results in saving of valuable production metals and materials. The chuck will take any type work whether round, hex, square or rectangular, and permits full efficiency of the operator, as it is operated by a foot operated valve thus leaving hands free to load and unload—reducing fatigue and cutting unproductive time to a minimum.

Wrigley's Spearmint Gum, too, is a help on the job. For chewing gum helps relieve dry throat, and helps ease fatigue brought on by the strain of work. And at the same time you are chewing and getting the benefits of swell tasting Wrigley's Spearmint, both hands are free and you need not take a "time out." The Army and Navy have recognized these benefits and are now shipping overseas *only*, all of the limited production of Wrigley's Spearmint. When Wrigley's Spearmint can again be produced in sufficient quantity for all, the valuable benefits of Wrigley's Spearmint Gum now being proven on the battlefield will apply to industry here at home.

You can get complete information from Redmer Air Devices Corp., 601 West Washington Blvd., Chicago 6, Ill.



An air operated collet holding fixture for precision chucking or machine tools



Chuck can be mounted on angle for angle milling job

Y-151

THE HENRY SYSTEM Of Finger Print Classification and Identification

is now in use by most of the Police Departments in the United States. It is also the system which applicants for many Civil Service positions must master before they can successfully fill all requirements.

The only book based on the Henry System is Frederick Kuhne's

"THE FINGER PRINT INSTRUCTOR"

In this 182-page book, written by a noted finger print expert who was for many years in the Bureau of Criminal Investigation, New York Police Department, will be found complete instructions on every phase of the work from taking the prints to final identification. Numerous photographs and reproductions of prints make all details clear.

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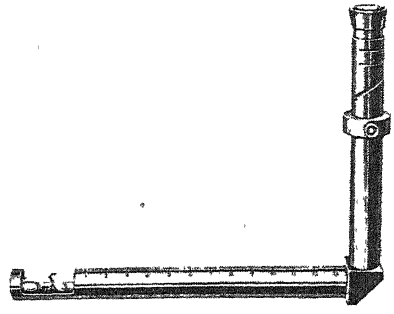
New Products

BORESCOPES

ORIGINALLY designed for the internal surface inspection of gun bores, Polan Borescopes are now available for use by private industry.

Borescopes have solved the problem of making the surface of long bores accessible to the human eye in order to inspect for minute cracks or other surface faults which may cause failure in operation. They are recommended particularly for close scrutiny of internal surfaces of bored engine shafts, tubular bodies, hydraulic and other cylinders, and so on and will cover a diameter range from 13/16 to 9 inches, and a bore length up to 30 feet.



Right-angle type of borescope

Polan Industries have developed a complete line of these industrial telescopes. The instruments combine the qualities of a highly corrected lens system and of excellent interior illumination with the demand for rugged design which is necessary for everyday machine shop use. They do not strain the inspector's eyes when operated continuously, and require no special operator training.

SHOT PEENING

TO INCREASE the life of stressed parts such as gears, springs, axles, torsion bars, crankshafts, connecting rods, milling cutters, pneumatic drills, and so on, by shot peening, a line of machines known as Wheelapeening equipment has been announced by American Foundry Equipment Company.

In the Wheelapeening machines, a rain of metallic shot is directed against the part at high velocity. Each shot striking the surface makes a tiny dent or pit, so that the cumulative effect is to stretch the surface layers by cold working, to put them in a state of residual compression. Since failure occurs under tension stress and never under compression stresses, fatigue cracks do not get a chance to start.

Within the Wheelapeening machine a Wheelabrator (airless, centrifugal blast unit) hurls a rain of shot at high velocity onto the surfaces of the parts to be peened. These parts are moved within the device so that all surfaces are exposed to the peening action.

The Wheelabrator is a mechanical unit that utilizes controlled centrifugal force instead of compressed air for throwing shot upon the work. It is completely airless, therefore it eliminates costly compressed air generating equipment. Shot is fed to the center of the bladed wheel from an overhead storage hopper whereupon it is hurled by centrifugal force, under perfect control, upon the work to be peened. Provision is made for continuous reuse of shot, for removal of broken shot and dust, and for addition of new shot to the cycling system.

FUNGUS-RESISTANT COATING

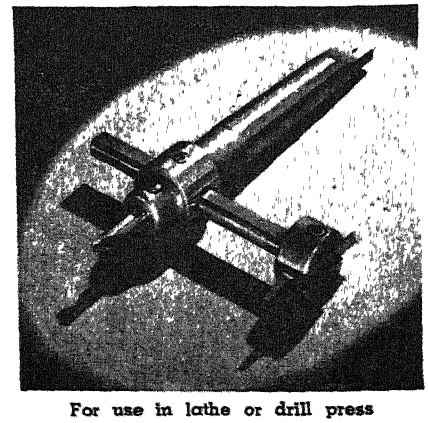
PHENOLIC parts of communications equipment to be used in tropical climates can be made fungus resistant by use of a coating developed by Mass and Waldstein Company. The coating is designed for application on phenolic insulators, terminal blocks, junction blocks, and the fixed windings of motors, generators, and dynamotors.

Marketed as Durad Fungus Resistant Coating #524, this fungus-resistant coating is a varnish and is applied by spray, dip, or brush. It has been successfully tested for dielectric strength, hardness, flexibility, and resistance to salt spray and thermal shock.

"Tropicalization" of communications equipment with fungus-resistant coatings is necessary because the high temperatures and humidity of tropical climates favor the growth of fungi. The growths cover the equipment and absorb moisture, causing short circuits and drifts.

CIRCLE CUTTER

CONSTRUCTED of heat-treated alloy steel, the new Rieger circle cutter has a cross-arm which is adjustable for holes of two to eight inches diameter. A ¼- by ¼-inch tool bit of any desired contour is fastened with a setscrew in the holder at the end of the cross-arm. The tool is designed to be used in a



For use in lathe or drill press

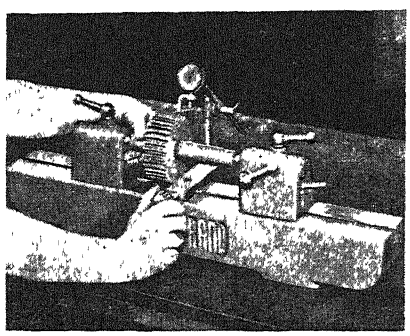
lathe, drill press, or electric drill, being centered in the work with a ¼-inch stub pilot drill

The tool is said to have ample strength for machining holes in ½-inch plate steel. By the use of a suitably ground bit, the periphery of the hole can be straight, chamfered, rounded, or stepped Obviously, the tool can be used for machining holes in metal, fiber, wood, and other flat materials.

BENCH CENTER

ACCURACY can be maintained to within limits of .0001 inch in checking for runout on a new improved bench center brought out by the Sundstrand Machine Tool Company.

Precision checking of work between centers is simplified and speeded by "one-handed control" over all movable



Precision checking is simplified

elements, which leaves the operator's other hand free to control the part being checked. Unclamping, positioning, and locking in place of both the heads are easily achieved with a single hand operating the top lever.

The center in the L H head is fixed but the center in the R.H. head is spring loaded and can be retracted by the end bar for quick loading and unloading. Front clamp on R.H head locks the center in position during checking operation. The indicator support is manipulated with one hand when moving it away from the work for loading and unloading and against the work when checking for runout.

WAX

FLOOR wax that can be sprayed on large floor areas, leaving a high-gloss, non-slip finish without buffing, is announced by Turco Products, Inc. The new product, Grip Wax, is designed to speed the application of wax in hospitals, schools, restaurants, factories, civic buildings, and so on, where heavy traffic requires frequent waxing applications.

The anti-skid safety qualities of the material insure secure footing on all types of floors, even reducing the well-known slip hazards of concrete floors, according to the manufacturer.

Grip-Wax is a free-flowing liquid which is easily applied with a light wiping motion or by atomizing spray rather than by arduous rubbing. It sets in a few minutes to a non-tacky, lustrous finish comparable to that usually obtained by vigorous buffing of expensive imported waxes. There is no solvent action on asphaltic tile, rubber, or linoleum. Grip-Wax seals floor pores and joints against water penetration, and tests show its flexibility resists constant traffic blows.

STORAGE FLASHLIGHT CELL

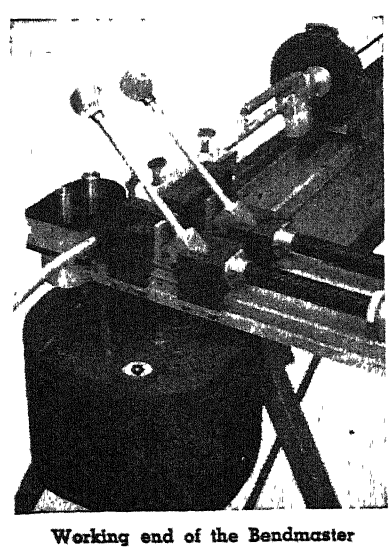
A RECHARGEABLE wet flashlight cell for industrial use, built on the principle of the automobile wet storage battery and especially valuable for operations where long continued and steady usage of flashlight is necessary, is announced by The B F. Goodrich Company. The company claims that the wet storage cells are more economical than dry cells when flashlight service is required in volume, or where batteries require replacements more than once every two weeks. A freshly charged wet cell will provide for about three hours of *constant* light Batteries can be used in the standard three or five cell dry battery case with the use of spacer plugs.

The new wet cell requires a special type Mazda Lamp, which comes in 1.9 volt, .6 ampere rating, with screw base and flange base design. This is a 600 mil lamp as contrasted with the 300 mil lamp used with dry batteries. Actual wattage consumed with the wet cell is 50 percent more than with the dry type and since light is directly proportional to watt consumption the wet cells produce a distinctly brighter light than the older type. The light is constant, since the voltage drop between a full charged and discharged wet cell is only 35 volts, while the dry cell drops approximately a full volt. This assures constant top quality light at all times.

TUBE BENDER

CAPABLE of producing 900 to 1000 bends an hour, a new manually operated tube bender has been designed by The Douglas Aircraft Company. An improved form is now being manufactured by Leonard Precision Products Company.

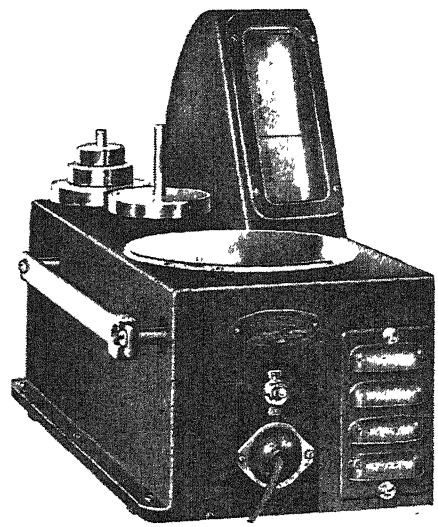
The Leonard-Douglas Bendmaster, as it is named, will handle non-ferrous tubing from ⅜ to 1¼ inch outside diameter tubing, producing from one to ten different bends in a single nine foot length. These bends can be produced to any specified degree of angle



Working end of the Bendmaster

Exact Weight Scales

Shadowgraph...



The Shadowgraph is a predetermined weighing unit, electrically operated. This precision instrument has completely revolutionized the task of fine weighing in fraction ounces, grams and grains. *Delicate weighing has in the past been a slow operation under glass protection for accuracy.* EXACT WEIGHT Shadowgraphs have changed all this. Fine weights can now be attained with absolute accuracy and speed of operation many times the old method. If you have a fine weighing operation you should have the details on this new and revolutionary scale which is geared to present day high speed industrial America.

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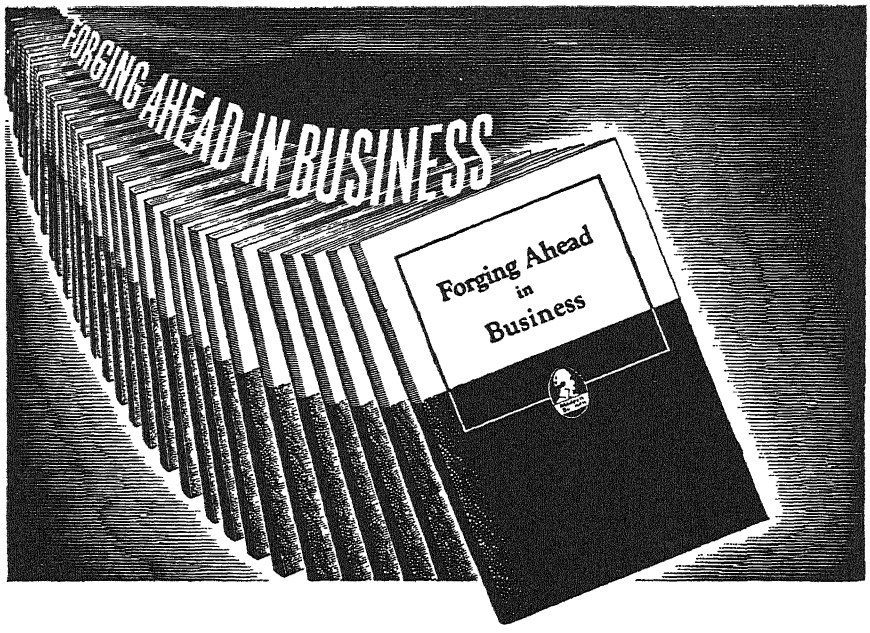

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Among the prominent industrialists who assisted in the preparation of the Course, which is described in "FORGING AHEAD IN BUSINESS" are: Alfred P. Sloan, Jr., Chairman of the Board, General Motors Corp.; Thomas J. Watson, President, International Business Machines Corp., and Frederick W. Pickard, Vice President and Director, E. I. du Pont de Nemours & Co.

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Frankly, this booklet has no appeal for the immature mind. It does not interest the man who, for one reason or another, is wholly satisfied to plug along in a mediocre job. But, for the alert, future-minded individual—the man with ambition and "drive"—"Forging Ahead in Business" has a message of distinct importance. If you feel that it is intended for you, don't hesitate to send for a copy today. Simply fill in and mail the coupon below.

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up to 180 degrees and at any radial angle Special models for tubing up to 20 feet are available.

Set-up time of the new machine averages 7 to 15 minutes The machine cam arrangement and automatic stops are adjusted according to specifications on the job ticket and the machine is ready for production.

A considerable number of these machines are now in operation in the major aircraft plants on the West Coast According to West Coast production men, the most important feature of the Bendmaster is its consistent duplicated accuracy of the bends even over extended production runs. Although originally designed for aircraft production, this machine can be utilized in speeding the production of many other industries.

STORAGE BATTERIES

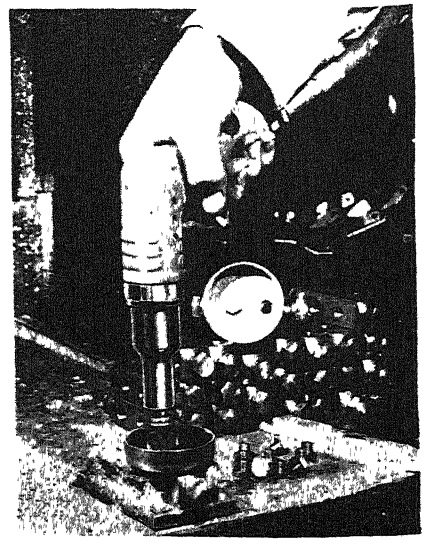
EMPLOYING the "vacuum-pack" principle which has been extensively used for preserving and safeguarding foods, an unusual type of storage battery, developed by the Willard Storage Battery Company, is now being mass-produced for use by our armed forces. Details of these new batteries and their unique packing have just been revealed.

Four batteries—three 36-volt types and one six-volt—are packed in a lead-plated metal container from which the air is exhausted. The batteries retain their charge indefinitely and are ready for immediate use regardless of the elapsed time since their manufacture or the distance they have been transported.

When the batteries are about to be placed in service, the can is punctured by a special filling device and the vacuum inside the can permits the electrolyte to move quickly into the vent holes in each battery. Thus, in a matter of seconds, each battery is filled with electrolyte and is ready to go to work

IMPACT SCREW DRIVERS

A NEW line of impact screw drivers and nut setters with positive torque control is announced by The Aro Equipment Corporation. A torque regulator, located in the handle, allows the opera-



Air-operated screw driver

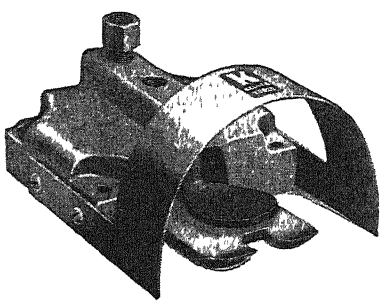
tor to easily regulate the torque necessary to tighten the screw or nut. There is ample adjustment to meet most screw driving and nut setting conditions.

Like the impact wrench described in these columns in October, this pneumatically powered tool operates with a roller clutch impact mechanism having only four major parts—anvil, hammer, and two cylindrical steel rollers. When in operation, the centrifugal force throws the two steel rollers out against the hammer, this transfers the full torque through to the work in the form of a sudden impact. When the selected torque is obtained, the rollers rebound from the anvil face and do not allow the hammer to engage for impact.

THREE-WAY FOOT VALVE

A COMPRESSED-AIR foot valve to be used with air tools, air cylinders, air chucks, flash welders, forging machines, die casting machines, riveting machines, air vises, and all other air-operated equipment is announced by Keller Tool Company.

On tools where it is desirable for operators to have both hands free, it greatly facilitates rapid handling of



Foot valve for compressed air lines

work. Safety of the operator is accomplished by the kick guard which prevents accidental operation.

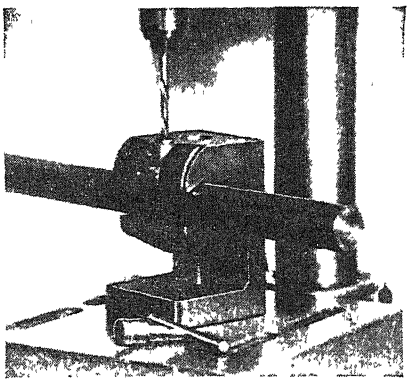
This foot valve is furnished in locking and non-locking types. The pedal lock on the locking type holds the pedal in the open position. A touch of the operator's toe releases the lock.

A simple adjustment of the lever-locking device prevents engagement of the operating pedal and changes the locking type to the non-locking type.

The valve mechanism is simple. Normally the valve is closed with the outlet side open to the exhaust. When the foot pedal is depressed, the exhaust closes and line pressure is admitted to the device to be operated. Upon release of the pedal, the air supply stops and the outlet to the exhaust is again opened.

ACCURATE VISE

A WORK-holding vise, the "Center Drill and Mill Vise," as manufactured by the Universal Engineering Company, embodies features which include accurate cross-center drilling of round stock. No moving parts are involved in this operation which guarantees permanent accuracy. The bushings through which the drill passes are interchangeable, giving a wide range in hole sizes. The vise will hold hexagon stock as well as round. Clamping action of the



Round stock is positioned accurately

vise is the opposed jaw principle, thereby leaving one surface of the work clearly exposed for slot milling and so on. All exterior surfaces of the vise are precision ground square and parallel, allowing it to be used in conjunction with any type of machine tool as a work holder to insure accuracy.

LOW-TEMPERATURE GLUE

A NEW synthetic resin glue for wood, which sets at ordinary room temperature, is known as Cascophen RS-216, and is used with a separate dry-powder catalyst.

Cascophen RS-216 can be stored indefinitely at room temperature. It has a marked "affinity for wood" and bonds at low pressures and on uneven surfaces. It cures in eight to ten hours at 70 degrees, Fahrenheit, or less at higher temperatures. The bond meets the most rigorous joint tests required by any current United States Government Specifications and withstands heat and moisture tests which destroy practically all other glue joints set without high heat.

This new glue is recommended for work where complete durability is required and where joints cannot be heated, such as the gluing of thick laminations for airplane propellers, heavy-duty built-up arches and beams, aircraft spars, and so on.

HYDRAULIC ACCUMULATOR

MANY new applications of hydraulics in the machine tool, automotive, railroad, and marine fields have been

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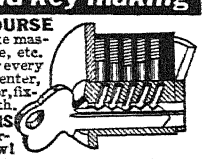

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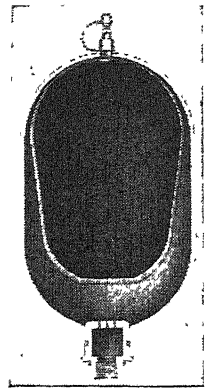
opened with the release of a low-cost hydraulic accumulator, formerly available for aircraft exclusively. Because of the tremendous size and high cost of previously available industrial type accumulators, the advantages of hydraulic actuation were denied to many types of presses, riveters, hoists, elevators, marine steering gear, brakes,



Cross-sectional view of the new hydraulic accumulator with a one-piece synthetic rubber bladder

and, especially, portable equipment. The new accumulator, manufactured by Greer Products Corporation, consists simply of a one-piece seamless steel shell, without welds or joints, containing a completely enclosed one-piece synthetic rubber bladder having an integrally molded air valve. It is made in capacities from 0 333 to 25 gallons.

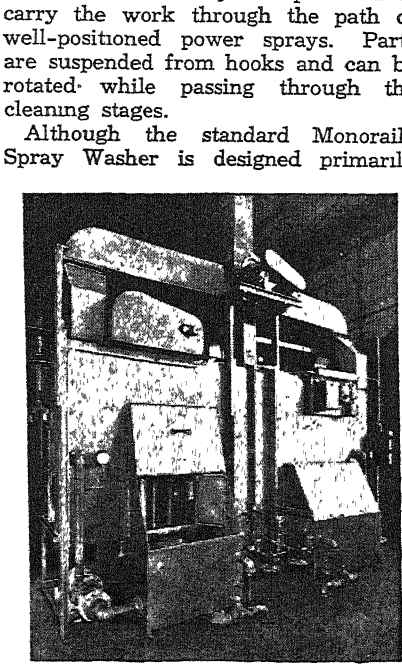
METAL WASHER

Developed by the Metal Washing Machine Division of American Foundry Equipment Company, a new and improved design in metal washing equipment, the Monorail-Spray Washer, is designed to handle metal parts which must be rotated while they are passing through the cleaning chamber for highest cleaning efficiency. Typical work of this type includes intricate circular parts or those with many ports, crevices, or openings.

A monorail conveyor is provided to carry the work through the path of well-positioned power sprays. Parts are suspended from hooks and can be rotated while passing through the cleaning stages.

Although the standard Monorail-Spray Washer is designed primarily for washing and rinsing operations, it is so constructed that additional units such as drying and rust-proofing sections may easily be added to the machine to suit variations in production setups

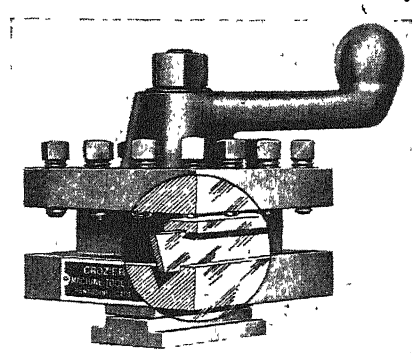
The unit can be equipped for heating with steam, gas coils, or electric immersion heaters. Thermostatic controls are furnished. To carry away steam and vapors, a ventilation ductwork is provided on the top of unit.



Metal parts are rotated while washing

TOOL POST TURRET

An improvement in tool post turret design is announced by the Crozier Machine Tool Company. The Crozier Tool Post Turret, the first to be made for bench lathes, is now specially adapted for cutting-off operations. One side of the block is channeled to receive a standard beveled section cut-off blade, which is supported at the top by a hardened channeled bar that provides maximum bearing surface for the locking bolts, thus quickly and positively centering and holding the blade in correct vertical position. There is no overhang of the holder and only sufficient tool extends to the required depth of cut.



Rigid, simplified tool post turret

It is stated that this arrangement assures rigidity, materially reduces set-up time, and increases production by chatterless operation.

CELLULOSE HEATER

A new electrically-heated tank has been designed by the Aeroil Burner Company, Inc., for heating, melting, and dipping ethyl-cellulose compounds

This unit features completely uniform, direct heating through the medium of an agitated hot oil bath that completely surrounds the material, and also places heat in the ethyl-cellulose by a new method. As a result, the manufacturer claims that completely uniform, indirect heat is distributed underneath, above, around, and within the ethyl-cellulose itself, without any possibility of localized over-heating, "hot spots," or degradation of the melt.

Both tank and removable cover are completely insulated. Tests have shown an overnight heat loss in the compound of only 10 degrees, Fahrenheit, per hour—with all heat shut off. Two thermostats automatically hold the oil bath at any desired temperature required by the particular ethyl-cellulose formulation being used.

Current Bulletin Briefs

Conducted by
K. M. CANAVAN

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

GENERAL SILENTBLOC is a 34-page thoroughly illustrated bulletin dealing specifically with flexible rubber bearings, mountings, and couplings. These units are designed for use with machinery and other equipment in motion to absorb vibration, allow torque action, and correct for misalinement. *The General Tire and Rubber Company, Mechanical Goods Division, Wabash, Indiana.—Gratis.*

IT WAS A TUBE THEY WANTED is an illustrated booklet telling a critical war story about the importance of electronic tubes in intricate and interesting plant operations. Plans for post-war developments are discussed. *Amperex Electronic Products, 79 Washington Street, Brooklyn 1, New York.—Gratis.*

ALOFT IS NO PLACE FOR A. W. O. L. BEARINGS is a four-page bulletin describing the application of a system for sending lubricants under pressure from a central pumping system to high-up and hard-to-get-at bearings on presses, cranes, and other "off the floor" types of equipment. *The Farval Corporation, 3428 East 80th Street, Cleveland 4, Ohio. —Gratis.*

SOUTH BEND PRECISION LATHES is a new eight-page condensed catalog covering engine lathes, toolroom lathes, and precision turret lathes for practically all types of production, toolroom, and maintenance work. All information concerning capacities, speeds, feeds, and dimensions is tabulated for each size and model of lathe. *South Bend Lathe Works, South Bend 22, Indiana.—Gratis.*

HOW ONE COMPANY ORGANIZED TO HANDLE WAR CONTRACT TERMINATIONS is a 12-page circular which presents a step-by-step view of the subject and gives a suggested breakdown of termination duties by departments. It illustrates 14 practice-proved forms which one company designed to expedite its work. The text may serve to alleviate many industrial headaches. *Lyon Metal Products, Inc., Aurora, Illinois.—Gratis.*

CORRECTING WATCH TIME BY WATCH VIBRATIONS explains a simple way to alter the speed of a watch temporarily to correct its time without opening the case. *E. M. Tingley, 221 North Cuyler, Oak Park, Illinois.—Gratis.*

PLASKON is a 16-page illustrated booklet presenting the uses of plastic materials for modern industrial production. Each type of Plaskon resin is thoroughly described, to encourage the correct application of plastics to specific requirements. A special section deals with Plaskon resin glue for commercial bonding of wood, paper, fabrics, cork, and compositions. *Libby-Owens-Ford Glass Company, Plaskon Division, 2138 Sylvan Avenue, Toledo 6, Ohio.—Gratis.*

THE HOW AND WHY OF FLEXIBLE SHAFTING is a 32-page fully illustrated catalog which deals with the possibilities of flexible shafting in a number of industrial fields, gives definitions of flexible shafts, outlines some of the jobs that flexible shafts can do, and presents data on their performance under varying conditions. *Stow Manufacturing Company, Binghamton, New York.—Gratis to requests made on business letterheads.*

HOW TO MEASURE IN MICRO INCHES is a 20-page thoroughly illustrated booklet which deals with the fundamentals of precision measurements and shows how these principles can be applied to production in the daily control of product quality. *Continental Machines, Inc., 1301 Washington Avenue South, Minneapolis 4, Minnesota.—Gratis.*

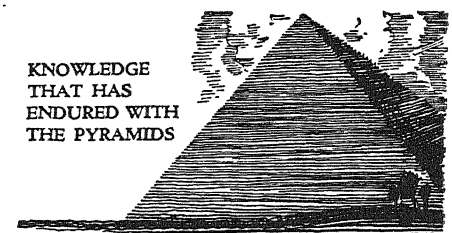
41 MORE WAYS REMOVABLE STICKERS SPEED PRODUCTION is an eight-page booklet presenting examples of the uses of Kum-Kleen stickers in identifying and marking parts in production. *Avery Adhesives, 451 East Third Street, Los Angeles 13, California.—Gratis.*

TOOLS TO BUILD THE WORLD OF TOMORROW is a 20-page brochure built around a portable electric drill in the design of which some revolutionary applications of plastics have been put to use. This one application foreshadows others. *Independent Pneumatic Tool Company, 600 West Jackson Boulevard, Chicago 6, Illinois.—Gratis to industrial executives who make their requests on business letterheads.*

WOOD AIRCRAFT INSPECTION AND FABRICATION—ANC-19 is a recently revised bulletin designed to speed the production of training planes and gliders. Its contents, however, will be of interest and value to anyone concerned with handling of wood. *Government Printing Office, Washington, D. C.— $1.00.*

HOW TO MAKE PATTERNS AND MODELS WITH GYPSUM CEMENT is a manual prepared to give designers, manufacturers, foremen, and workers in the metals and plastics fields a clear understanding of the latest developments in gypsum cements and how they can help to solve problems of production design and reproduction. *United States Gypsum Company, 300 West Adams Street, Chicago, Illinois.—Gratis.*

FLEET-WELDING is a 48-page semi-technical treatise on a new method for increasing the speed of welding mild steel. A number of photographs and drawings illustrate the technique and 17 tables present procedure data. Request bulletin Number 440. *The Lincoln Electric Company, Cleveland 1, Ohio.—Gratis.*



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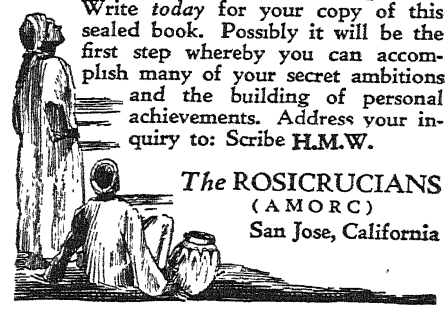

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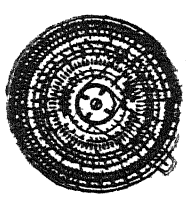

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Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

THIS, now that it can be told, is the second half of the story of the recent Roof Prism Program of Scientific American's advanced amateur telescope makers.

In the first account, published in the May 1943 number, it was told how Russell Porter, Alex MacTavish, and your scribe, had discovered in 1941 that the nation's need for roof prisms for military instruments was desperate. Roof prisms (Amici type) were suddenly needed by scores of thousands but there had been no peacetime demand and only two or three precision opticians had learned how to make them. They were about the toughest thing to make in optics; two of their faces had to be within two seconds (1/1800 degree) of a perfect right angle, or 60 times as close as the Porro prisms in binoculars and far closer than all but the most uncommon right-angled prisms.

It was told how this magazine arranged with Frankford Arsenal to be the link between that institution and the amateurs, and how it organized 100 of the more able amateurs and throughout a year and a half coordinated their work while they progressed from single trial prisms to small and then large orders, working at home. Into this program Russell Porter threw the weight of his prestige, inspiration, and all the help he was able to give. The third leader, MacTavish, had foreseen the nation's need for the difficult roof prism and, working alone and without written instructions (none then existed), had ferreted out the technique. He had patriotically turned over to the 100 amateurs, through mimeos issued by Scientific American, all that he had learned, enabling them to start level with him. Who was MacTavish?

"MacTavish" was the alias for Fred B. Ferson, Biloxi, Mississippi, which had to be assigned when the Office of Censorship, after going over the manuscript of the account of May 1943, said: Give all the roof prism producers fictitious names and, for fear of sabotage, omit their locations. "MacTavish's" (Ferson's) photograph has been in "Amateur Telescope Making — Advanced," page 337, for years.

Thus the man who, out of patriotic motives, gave hundreds of tired hours to others and answered hundreds of letters while busy making his own roof prisms, was simply one of the nation-wide fraternity of glass pushers—an average three-mirror amateur when he began making prisms. It is ironical that wartime necessity forbade revealing the identity of the amateur who gave the most to the Roof Prism Program.

Here is a summary of the roof prism production of the amateurs—the prisms actually accepted and purchased by Frankford Arsenal and three large wartime military instrument makers. Most of the names look more professional than amateur. This is because assuming formal company names proved easier than to convince a puzzled world that amateurs could make roof prisms.

No conclusions should be drawn because of the large variation in production of the individual amateurs. Some unwittingly began almost too late; others lacked time or strength for the exacting work, which experience proved to be too strenuous for performance in spare hours.

F. L. Frazine, jeweler, St. Petersburg, Fla., 18 prisms.

F. A Jasset, podiatrist, with F. Richards, Newton, Mass, 24 prisms.

G. E. Gordon, photographer, Natick, Mass., 25 prisms.

F. R. Varela, engineer, Tenafly, N. J., 50 prisms.

A. H. Johns, decorator, Larchmont, N. Y., 165 prisms.

G. Dallas Hanna, zoologist, paleontologist, California Academy of Sciences, San Francisco, with others of the Academy museum staff, made 165 prisms but shifted to emergency repair of Navy optical instruments.

K. E. Dykoski, assistant in astronomy, University of Minnesota. 300 prisms.

The Precision Military Optical Co., H. H. Selby, Encanto, Calif., 700 prisms. Selby later turned to essential war work in his vocation, chemistry.

The Wellsville Optical Co., Wellsville, N. Y., David Broadhead (the "Jim Fogarty" of the May 1943 account) assisted by two part-time employees and by Mrs. Broadhead in the capacity of prism inspector, cleaner, and packer, food provider, and sympathetic listener to beefs and griefs, individual and collective, 1850 prisms. Broadhead's vocation, doctor and bonesetter to the motion picture projectors of S. W. New York State, afforded him considerable spare time.

The Emerson Optical Co., Inwood, N. Y., Ralph Franklin, engineer, and Frank Cameron, assisted by Mrs. Cameron and one employee, were the only ones who made a large number of prisms (1700) in spare time, after doing full days' work in their vocations. For this they paid the penalty of creeping fatigue.

The Optical Associates, of Detroit, L H. Sampson and several other amateurs, made 4500 prisms—which, however, was only a part of their general optical work. They plan to remain permanently in optics.

The Modern Optical Co., Toledo, 7300 prisms, consisted of Wm. Buchele, an amateur who had made a 20" reflector described in this department October 1939, assisted by his father, son, wife, and brothers, whom he trained to do some of the processes. He remains permanently in optical work

Ferson-Linde Optical Co, Biloxi, Miss, 11,160 prisms, was Fred Ferson of Biloxi and Paul Linde ("Pavel Uvaroff") of Crossville, Tenn., assisted by one full-time helper trained to do grinding. Ferson remains in optics as head of the Ferson Optical Co, Biloxi, while Linde, in Crossville, Tenn., is doing individual optical jobs on the side, as he had been doing before the war. Like the rest, these two pitched the time-clock into the well and worked from 8 A M. till 9 P.M. till they were fagged—and then kept going.

The total production mentioned above is 28,420 Amici roof prisms accepted and purchased at prices which ranged somewhat above and below ten dollars each

What percentage of the total roof prisms produced in the nation the 28,420 represents cannot yet be stated and is not large—probably under a tenth part. Where the amateurs made up for this, and more than made up, was in quality. Their percentage of prisms accepted by Government inspectors was higher than for all or nearly all the professional producers. This is not, however, a reflection on the professional. The amateur was running a small shop and doing his own work, or the finer parts of it, himself. He had high incentive—interest in optics as a science—and, above all, personal pride derived from his telescope making days. The professional seldom could employ men having the same incentive. In other words, had the amateurs greatly expanded they, too, would have had to employ wage earners for the finer parts of the work, and then their level would have had to fall to the common level, which ran from 80 to 90 percent acceptance of prisms submitted; in a few instances higher Not all the amateurs even equalled this level but most of them considerably exceeded it. Buchele, Broadhead, and others ranged around 98 percent On their 11,160 prisms Ferson-Linde bettered 99½ percent acceptance by purchasers

As Ferson pointed out in these columns in May, 1943, the telescope maker is judge and jury of his own work but when optics are sold to others a disinterested, tough, and hard-boiled, impersonal inspector steps in. Suppose, for illustration, the same rigorous standard were applied to the mirrors you make. For one single pit a mirror would be rejected, or for one tiny scratch visible only under a ten-power glass perhaps after you had been shown just where to look. How many mirrors would get by? That is what the prism makers encountered—greatly stepped up requirements (not a bad thing,

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however, since compromise would only beget more compromise, then laxity).

The amateur had much more skill compared with the field—a major part of which consisted either of new firms without optical background or old non-optical firms thrown into optical work because it had to be done by somebody—than was sensed at the time. Had this been sufficiently realized nothing would have been allowed to obstruct a plan which Porter, Ferson, and your scribe at first projected the gathering of the amateurs in one place and in one organization—Amateurs Incorporated. To this, two obstructions arose. One was the simple fact that, until the amateurs' own ability to do this optical work of the toughest kind equally well with professionals had been demonstrated—a thing which required so long a time that the demand for roof prisms was largely filled by the time that they knew they could successfully do it—they dared not quit their regular jobs and make the leap A second was the fact that a certain professional optician was able to convince authorities that amateurs never could make roof prisms. The man who accomplished this questionable end did so at a critical time when the nation's need for roof prisms has been described as desperate At best he used bad judgment. At worst his outlook was constricted.

When World War III comes (compare with the history of Rome's three Punic Wars, in the third of which Rome virtually erased Carthage when Carthage was once more found to be rearming) let the amateur hit his optics early, hard, and unitedly, and with no inferiority complex.

SINCE Ferson, starting with average advanced amateur background (three mirrors, a flat, a lens), devoted three years of intensive concentration to optics and learned a lot which daily work of the same kind afforded frequent opportunity to check, this department recently invited him to write out for the benefit of other amateurs and professionals the boiled-down juice of his experience; and since two chapters in "Amateur Telescope Making—Advanced" (those on the Gaviola and Zernike tests) had aroused little interest since their inclusion seven years ago, these have now been replaced by a single 29-page chapter by Ferson, entitled "Prisms, Flats, Mirrors," in a new printing of that book. In the same printing Dr. John Strong has completely rewritten his chapter on mirror aluminization and has included in it some new and valuable working pointers. The book is still Edition 1 but is now the fifth printing of that edition, and is revised to the extent of a total of 39 new pages.

In his 29-page chapter Ferson gives the essential principles of prism manufacture for large- and small-scale production, also for hand production of small batches from a dozen down to pairs and singles—the singles being polished and corrected within annuli of plate glass for easier control by the tyro.

He gives a list of prism-making equipment and some dodges for avoiding too heavy investment on small jobs, compared with the value of the prims.

He tells how to grind a prism to a close angle before polishing, a very pretty and labor-saving art.

He explains how prism face angles are tested

He explains the exquisite art of correcting, freehand, the polished prism faces This is the final process and the one calling for the greatest skill, but also is the most interesting one—rubbing off single seconds of arc with a few simple strokes (simple if you know how!).

For prisms, flats, and mirrors, Ferson lays much greater stress on grinding than our art has ever called for before His intensive experience revealed grinding to be just as important as polishing and no longer a perfunctory, merely mechanical, preliminary process. The practical dividend from supergrinding is the avoidance of such ills as turned edge. Ferson thus pursued one source of turned edge into its hole and dug up the hole—found the basic principle involved and devised a remedy, a part of which includes the use of a channeled glass tool for grinding, a talc-emery mixture, and drying up the wets. One hour per stage also is now held to be too little with Pyrex.

The relation between prisms and flats may seem remote but actually is immediate: prism making is flat making. Prisms have flat faces but, even more to the point, they are blocked in batches in plaster matrices and thus are elements of a single big flat Before the beginning of polishing, a flat can be ground within half a wave of the ultimate

For polishing, Ferson finds that scratches are not attributable to hard laps.

He uses onion sack for sub-facetting and a rosin-pine tar mixture for the lap

The main secret of success is the use of the dummy polisher for keeping the lap itself flat; the same dummy is used in keeping a lap dead flat for hand correcting prisms.

Ferson's work brought out the vital importance of correctly conditioning the rouge after applying it.

Some rules of heat effects are stated.

Finally, in his chapter, Ferson applies his prism and flat technique to mirror work, with the same channeled tool, same drying up of the wets, as precautions against turned edge inherited from grinding. But the dummy obviously can't be used on a non-flat surface. Mirrors are polished face up

Not all these methods are claimed by Ferson; some are old. Mainly they are modifications of our amateur technique which protracted, intensive work brought out as more important than we amateurs had previously realized Some of them seem radical, yet 11,16(roof prisms with an acceptance per centage of better than 99½ seems t(commend them. Proof of the pudding

Ferson now does professional work yet remains amateur at heart, still freely giving his experience to th fraternity, as in the new "A.T.M.A. *Amo* means to love. The amateur i one who works for the love of it.

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COVER: An instrument repair man at work oiling one of the automatic temperature controllers in the control room of a fluid catalytic cracking unit now producing high-octane gasoline. The fluid catalyst technique, as pointed out in the article on page 250, holds promise for other uses in the chemical industry Photograph by courtesy of Standard Oil Company (New Jersey).

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Previews of the Industrial Horizon

By A. P. Peck

IN 1945, Scientific American will be 100 years old Plans for celebrating this anniversary have been perfected, are well underway. To attempt here to tell you all about the celebration would spoil a surprise, even if space permitted details. Regular readers will open their eyes; new readers will do well to reserve copies in advance, because war-time restrictions will limit numbers of copies available of the 12 special Anniversary Issues that will begin with January.

That much can be said now, and this much more: Two new sections will be added to each issue and three new contributing editors will join the brilliant group of specialists who now bring to Scientific American readers the broadest view of progress in science and industry obtainable in any periodical.

The two new sections will be "Plastics in Industry" and "Transportation." Editing Plastics will be Charles A. Breskin, Editor and publisher of *Modern Plastics*, who probably has done more for the plastics industry as a whole than any other one man.

Transportation will be divided into Railroad and Highway transportation, with Contributing Editors alternating from month to month. In January you will find the first railroad article by C B. Peck, Managing Editor of *Railway Mechanical Engineer*, who has been identified with railroading for so long that he knows his subject thoroughly from ballast to whistle

In the February issue will come Leslie Peat, Managing Editor of the *S.A.E. Journal*, writing on the general subject of highway transportation. Mr. Peat has an intimate daily contact with automotive transportation, and a faculty of digging deeply into the real meat of his subject.

These new sections in Scientific American are "plusses" in the sense that they will start coincidentally with the first of our Anniversary Numbers. The real treat of the year will be a series of monthly inspirational surveys of the background, the present, and the probable future of various phases of industry, as seen through the eyes of experts in the fields, culminating in one bang-up issue which, it is predicted, will become a collector's item because of its unique content.

PLASTICS' CONTINUING STORY

WHILE there is no thought of making a book-review section out of this page, it is impossible to resist the temptation of "lifting" a quick view of the plastics horizon from the book "The New Plastics," in an attempt to show quickly and in one glance the extremely broad fields that these industrial materials can and will cover.

One plastic is called a "synthetic mica", another is more nearly like glass than any other plastics· still a third is a synthetic rubber with high resistance to oil, gasoline, heat, light, and oxidization: one more has a strength-weight ratio in one direction higher than that of stainless steel; others make ideal adhesives for other materials.

Even such a brief listing as this acts as a spark-plug to start the imagination going along the plastics highway of the immediate future

THE UNSEEN IN THREE DIMENSIONS

TO THE tremendous advantages of extreme magnification offered to science and industry by the electron microscope has now been added the feature of three-dimensional viewing. With these three-dimensional pictures, made available by the application of the Polaroid vectograph system, it becomes possible to study and measure the shape and space characteristics of invisible structures that are extremely difficult or impossible to see in ordinary electron-microscope photographs.

The three-dimensional vectographs were first demonstrated recently by Robert D. Heidenreich, of the Dow Chemical Company, where they are being used in the investigation of corrosive phenomena in magnesium alloys Says Mr. Heidenreich "We can now examine the shape of micro-structures just as we can examine the formation of rock in a quarry. The increasing store of knowledge of new characteristics of metals will doubtless be utilized in the development of new alloys that perform even better than those we have today"

POST-WAR MOTOR-CARS

MORE modest than a maiden with her first boy friend are most of the motor-car people when pressed for definite statements regarding their plans General Motors has nothing to say except that they can get into production in a hurry, once they get the green light. Nash has ordered machine tools and factory plans for post-war production, but remains quiet on details Graham-Paige comes the nearest to being the Sunday-supplement writer's delight by saying that they will by no means be the first to get into production but that when they do it will be with a motor-car that will be "as modern as tomorrow." Ford, it is reported, has big plans for little automobiles but will not enlarge on that statement. Ex-Ford-man Sorensen, now president of Willys-Overland, is plumping for the jeep and predicts that that great little vehicle will have a brilliant post-war future, in fact, he foresees it as repeating the history of the Model T after World War I

All this makes good but still somewhat unsatisfactory food for thought. From this vantage point, any money to be bet still goes on the probability that motor-cars post-war will pick up where they left off with war-born refinements, and carry on through sane, reasonable developments. Old Man Public is a funny fellow about his automobiles, as quite a few manufacturers have learned who attempted to produce and sell "futuristic" motor-cars in competition with established, tried-and-true designs

FOR FUTURE REFERENCE

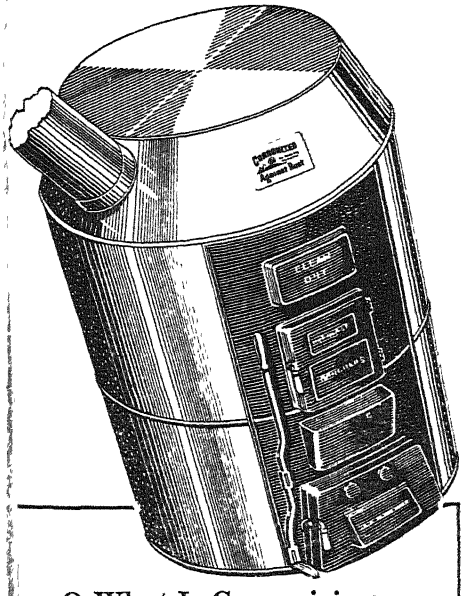
HOME-FURNACE fuel, in the form of three-inch cubes composed of anthracite and bituminous fines, held together with an asphalt binder, is in the offing. . Companies that give attention to the eyesight of their employees are finding that it pays dividends in increased production and contented workers. . If you are thinking about the highly efficient aircraft heaters now in use as a possibility for heating your post-war home. forget about it; it just isn't in the cards until many of the bugs have been eliminated The better the fuels developed for internal combustion engines, says Charles F. Kettering, the greater the improvement that can be made in them by the addition of ethyl fluid. . . Agriculture and industry are coming closer together; more and more agricultural products are finding pharmaceutical and industrial use. . Developments in fuel injection for gasoline engines foreshadow a possible return of the two-cycle system and direct competition with the Diesel in power and economy. . . Electronic devices, now multiplying like the proverbial rabbits, must, if they are to be successful, be regarded as something to be engineered into the whole rather than as gadgets to be attached at will. . . If you want to stir up an argument with a marine shipping man, bring up the question of what is to be done with the relatively slow Liberty ships after the war; right now they look like fodder for a peace-time scrap drive.

Look for this Label

On the Casing of Your Next Furnace

CORRONIZED
For Enduring Protection
Against Rust

...Because CORRONIZING MAKES METALS LAST UP TO 4 TIMES AS LONG!



Q. What Is Corronizing...

A. Corronizing is an inexpensive, tissue-thin armor against rust made an integral part of the metal by a patented combination of electroplating and heat treatment. Corronized metal can be formed, drawn, welded, soldered, sheared, blanked, pierced or embossed without material loss of rust-resistance, and offers an ideal bonding surface for paint or other finishes **Sales and production executives are invited to write for complete information.**

WHEN YOU can get up to four times as long service for your money—just by looking for a label—why accept less? That's just what it means in extra value, when a manufacturer puts the "Corronized" label on his products!

On the jacket of your next furnace or air conditioning system—and on stove or furnace pipes—the "Corronized" label means up to four times longer life before rust destroys the usefulness you've paid for. It's your guide to entirely new value in scores of other metal products, too... in automobile mufflers and parts—in hot water heaters and electrical equipment—farm equipment and window screens—and in scores of other metal products.

Corronizing is a new, proved, far more effective protection for metal against the rust damage that robs Americans of a billion dollars each year. The Corronizing process is the result of years of research by Standard Steel Spring Company, leading producer of specialized steel products—and has proved itself on vital products at the fighting fronts.

The Corronizing process is already available to all makers of metal products. Soon, on more and more metal items, you'll find the "Corronized" label identifying four-times-greater values. Look for it—ask for it. It's your assurance of products that will defy the ravage of rust up to four times as long.

CORRONIZING

Division of

Standard Steel Spring Company

DEPT. B-4

CORAOPOLIS, PENNSYLVANIA

Other peacetime products of Standard Steel Spring Company are automobile bumpers and springs, precision mechanical coil springs, universal joints, floor gratings and stair treads

Victory Is Still Many Dollars Away. Buy War Bonds.

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of December, 1894)

AIRPLANES — "Experiments with Prof Langley's flying machine have been in progress for some time past . This in connection with Maxim's work, goes far to indicate the possibility that we may yet see a successful aeroplane flying machine"

ALPINE ELECTRICITY — "An American traveler in the Tyrol and other Alpine countries gives an interesting account of the manner in which the Alpine torrents are being utilized in the Swiss villages . The streets in many cases are as brilliantly lighted as Broadway There are clusters of incandescent lights strung across the streets every few yards . . It is probable that extensive manufacturing interests will soon spring up and the mountain torrents will turn saws and spindles as well as dynamos"

WELDLESS CHAINS — "Mr. O Klatte, the manager of the Walzwerk Germania, at Neuweid-on-the-Rhine, has recently successfully worked out a system of manufacturing weldless chains, in which all the tedious operations of repeated heating, forging, and punching are avoided. This is effected by simply rolling the chains . The original form is a bar. This is passed between four rolls . After leaving the rolls, the chain bar is passed through a punching machine, with automatic feed, by means of which the webs are removed . The chain bar, of which the links are still connected by a slight web where inaccessible to the punches, is reheated to a red heat and passed under a press, by which the links are reduced to the specified width."

ALCOHOL — "Vivien and Dupont have experimented as to the manufacture of alcohol from apples One hundred quarts of apple juice, weighing 233 pounds, contained the usual water, 0.03 percent of ash, 2 04 percent of pectin bodies, and 2 percent of cane sugar, 2.97 percent dextrose, 8 50 percent levulose, and 0 84 percent of other sugars; total sugars, 14.31 percent. On adding phosphoric acid, potash, and ammonia (or sodium nitrate) the fermentation proceeds as quickly and completely as with turnip juice, and by this means 5 percent of alcohol is obtained from the apples."

SODA — "California is one of the few localities in the United States where natural soda is found. The geographical occurrence of this substance in the United States is principally confined to the arid regions of the Great Basin, especially to the soda lakes near Ragtown, Nev; Mono Lake, Mono County, and Owens Lake, Inyo County, Cal., and Albert Lake, Ore ; and to many dry deposits and incrustations in the same region"

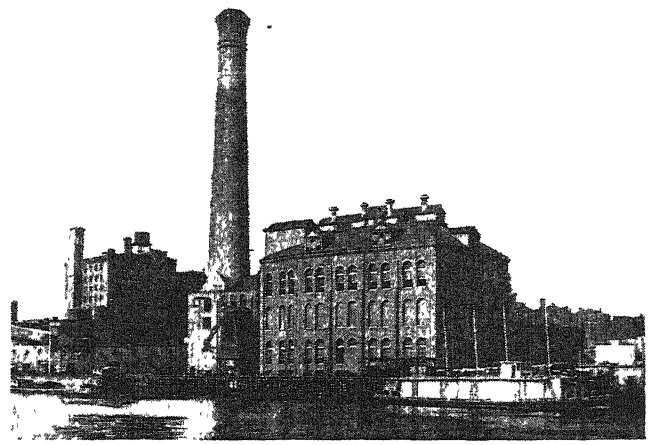
TALL BUILDINGS — "The contour of the city of New York is undergoing a very striking change in the increasing number of tall office buildings now being erected. The construction of these buildings is made possible only by the use of steel frames. . . The modern tall office building has a steel frame This carries nearly the whole weight, and the walls, solid and massive as they appear, do not support the structure, but simply fill the interstices."

FLY WHEEL — "Among the most recent and novel applications of wire, perhaps none has greater interest to the mechanical world than that presented by the new wire fly wheel lately erected at the Mannesmann Tube Company's Works. . . The wheel . . . consists of a cast iron hub or boss to which two steel plate disks, about 20 feet in diameter, are bolted The peripheral space between the disks is filled in with some 70 tons of No 5 steel wire, completely wound round the hub, and the tensile resistance thus obtained is far superior to any castings"

POWER LOOMS — 'In mechanical weaving the progress has been great, not only in the quality and character of the work done, but in the amount of production There is scarcely a woven design that cannot now be produced on the power loom But the advancement in power loom weaving is more appreciated in the speed at which the loom can be run and the facility with which it can be tended'

STEAM DEFENSE — 'A simple and effective method of repelling train robbers by discharging jets of steam upon the attacking party has recently been patented by William H Reeve, an old tugboatman, of New York A further use of steam as a means of defense, the inventor claims, would be in protecting banks against thieves A more ambitious plan, however, is to utilize steam in the defense of forts, armories or arsenals"

POWER STATION — 'The Eastern Power Station of the Brooklyn City Railroad Company, situated on the banks of the East River, in Brooklyn, N Y, from the electrical and mechanical aspect is undoubtedly one of the most perfect steam and electric plants in existence Thirty-six Babcock & Wilcox tubular boilers are eventually to be introduced The chimney is of brick and rises to a height of 296 feet,



and contains a circular shaft 17 feet in diameter. It is not only available for natural draught. Into its base a species of nozzle or intake is built, to which are connected two 12 foot Sturtevant blowers When these are in operation, a torrent of air is injected in the base of the chimney and acts injector-fashion to produce a draught The advantages of this system are that it dispenses with the necessity for closed ash pans or boiler rooms"

CAR CLEANING — "A novel use of compressed air has recently been made by some Western railroads Jets of air discharged from flexible hose are made to do the work of brooms, whisks and cloths in removing dust and cinders in passenger cars."

NIAGARA POWER — "Engineers have estimated . . . that the total water power of Niagara Falls is 7,000,000 horsepower This estimate, to be sure, is in the main only a guess, but when the area drained into the lakes above Lake Ontario, and passing through the Niagara River, be considered, the guess or estimate does not seem to be too large."

INVENTION — "'One of the best opportunities for a young man to make money quickly in these days,' said a self-made millionaire. . . . 'is to rack his brains until he has invented something useful or that the public wants. A general impression prevails that it takes a skilled engineer or a man of phenomenal inventive ability to develop anything useful to manufacturers in this age of machinery. But there is a wide field open to shrewd amateurs, so to speak, to supply little articles of convenience to housekeepers, shopkeepers, etc.'"

If You're Waiting for a Home Telephone

If you are waiting for a home telephone, we think we know how you feel.

You'd like a telephone now—not weeks or months from now. And we'd like to install it for you now.

But due to the war we are short of switchboards and telephones, so there will be unavoidable delays in filling orders for home telephones.

The delay will be as short as we can make it. Meantime, we are genuinely grateful for all your patience and co-operation.

BELL TELEPHONE SYSTEM

POST-WAR PROSPERITY under wraps

Machines for making passenger cars were stored away when America went to war. Soon they will produce civilian automobiles and jobs again—and here's why they will be better automobiles than ever before!

▶ Producing 6,000,000 automobiles a year will provide many a postwar job.

The metals, rubber, fabrics, glass, ceramics, plastics, electrical parts and other materials consumed by such production will help to stimulate many industries.

Every car manufacturer will produce to the limit at first—and for some months after "the wraps" are taken off. All cars will be "easy to sell." But after most of the essential replacements are made—what then?

Early in the post-war period, cars will undoubtedly become better looking, more comfortable, easier to handle and drive. But the most significant progress in motorcar design will depend—in the future, as in the past—*upon the development of engines that get more work out of each gallon of gasoline.*

A big step in this direction has already been taken. Immediately after the war the petroleum industry will be able to supply gasoline of far higher quality . . . gasoline that *in engines designed to utilize it* will give more power, more mileage, better performance. Thus, the *foundation* for more efficient engines is already laid.

ETHYL CORPORATION
Chrysler Building, New York City

Manufacturer of Ethyl fluid, used by oil companies to improve the antiknock quality of aviation and motor gasoline.

ETHYL CORPORATION

Wartime progress by America's petroleum industry has paved the way for fundamental progress in post-war automobile engine design.

ENGINEERING

Conducted by EDWIN LAIRD CADY

Courtesy International Harvester Company
The power transmission is completely enclosed for safety

Power Transmission Tamed

Factory Power Transmissions, Once Great Accident Producers, are Now Among the Safest Things in the Shop. Further, they are Quieter, More Efficient, More Accurately Controllable than Ever Before. They Absorb Vibration and Shocks, Protecting Machines and Power Sources Alike

WHEN the dust of battle finally settles, and industrial historians look back to see what changes have been made in factory practices, the advances in the mechanical engineering of power transmission are going to be found among the most valuable.

Only an old timer looking back at the factory of yesterday and comparing it with the one of today could see how great those changes have been.

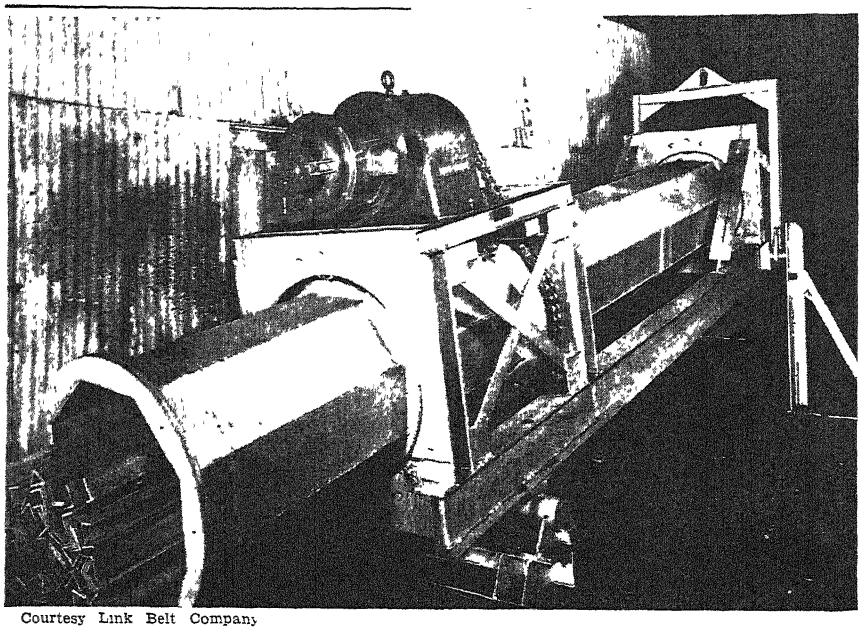
Power transmission, for example, used to be one of the three greatest producers of accidents. Now, modern guards and casings have made it one of the safest things in the shop

Much of the noise once considered so necessary to industry used to come from the whirring, slapping, squealing, grinding, and vibrating of power transmission devices. Now, power transmission is not only one of the quietest elements, but it actually is used to absorb and dampen noises made by other equipment.

Shop lighting once was made very difficult by power transmission which got in the way of any attempt at flood lighting or indirect illumination. Optical illusions caused by the movements of power transmission devices used to cause errors and accidents Now the power transmission is out of the way, arranged so it causes no optical illusions, its guards and casings especially painted to promote the effectiveness of shop lighting.

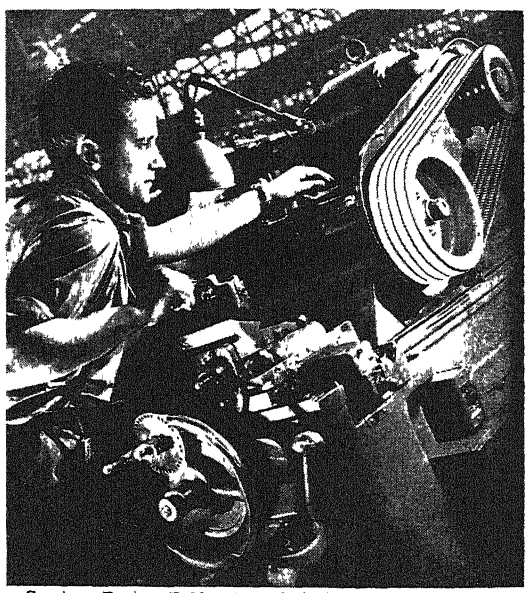
The portability of powered tools, drills, welders, grinding machines, and the like, used to be held down to the negligible point by the difficulties of connecting such machines to sources of power. Attempts to build individual engines or other power plants into this equipment were beaten by the sizes and bulks of the power transmissions involved. Now there is no basic type of production machine which has not been made fully portable. Machines which never were intended to be portable, such as drill presses, milling machines, furnaces, looms, are kept permanently mounted on skids so they can be moved from point to point in the production line or from one production line to another whenever the product to be made is changed enough to make a changed production operation sequence desirable.

One of the largest automobile makers, for example, keeps thousands of machines on semi-permanent mountings. If a machine breaks down and has to be repaired, or its tools need replacing, it is unbolted from the floor, picked up by the shop crane and taken to the repair department. The crane then picks up a fully tooled similar machine and places it in the production line. The production never is interrupted for more than a few seconds. Such tactics would have seemed impossible to the manufacturer of a few years ago. But modern power transmission with its easy adaptability has removed



Courtesy Link Belt Company

The revolving drum of this rotary cleaning and coating machine for hot rolled steel imposes tough shock loads, but the motorized chain drive takes them



Cog-belts were chosen for this job (right), because they operate on short centers, provide close speed control, and deliver smooth power flow at high speeds

Courtesy Dayton Rubber Manufacturing Company

the production tie-ups which used to be taken for granted when key machines ceased to function

Portable powered tools were really born in the desperate production problems of ship building and aircraft building during days of World War I Power sources such as compressed air, electricity, hydraulic pressure, or even steam were all ready for these tools But users took short life on the job for granted The motors or engines would stand up, and so would the hammers, chisels, drills, or other tools which were being driven It was the power transmission—the bearings, gears, clutches, and the like—which failed after a few hours of service

Now these same tools are out of the "emergency" class, and into the "taken for granted" group. Their bearings and gears have been made more accurate, because anything which moves can be strengthened enormously by measuring to the order of .00001 inch instead of .001 inch. Metallurgy has supplied alloys and heat treatments which can take the shock loads, the temperature differences (a shaft in a portable powered tool may be hot enough to turn carbon steels blue at one end, but be ice cold at the other), the metal rending torques which the power transmissions of portable machines must handle within the smallest possible spaces Electric, pneumatic, and all other kinds of motors have been greatly increased in power while being reduced in size and weight, gasoline engines with their pulsating loads on the power transmissions have been made in tiny sizes for portable powered tools, and still the modern power transmissions stand up and take it

PRECISION POWER—The exactness with which modern power can be made to function is one of the brightest promises to the machine designer of the future.

Electric motors of today take advantage of this exactness. They can be made to deliver torques (twisting forces) which are within a few pounds or ounces of the amounts desired. With such motors the machine operator can work right up to the limits of power which his tools and materials can take, knowing that no sudden surge of power from the motor will come along to break anything and that no diminishing of power will throw his calculations out of whack. But all of this exactness would be useless to him if he did not have similar accuracy in the performance of his V-belts, flat belts, chains, gears, hydraulic devices, clutches, and other power transmission members The only power that counts is the power applied at the point of work. Exactly controllable and functioning power transmission is what gets the exactly controlled motor power there

Metal cutting makes use of this exact control. The modern machinist determines the depth of cut in inches he will make, and knows that this, times feed in inches per minute, times surface feet per minute at which the tool will be in contact with the work, times a constant which varies with the metal to be cut (see table), equals the horsepower required for the cut. With this knowledge he can mount an electrical gage on the motor which drives his machine and if that gage does not show that the right amount of power is being used then he knows that something is wrong But all such devices would be useless if the power transmission would not deliver the power exactly as the motor produces it or exactly as it is required The old-fashioned machinist with his non-uniform power transmissions and his fluctuating sources of power had to work by judgement and instinct, he had to keep within safe limits and could not approach the outputs on similar operations which his modern competitor obtains

Ability to protect both the driven machines and the prime movers (motors, engines) is engineered into modern power transmission

Such power-driven tools as saws, milling cutters, and even some reamers, can set up destructive vibrations. The individual teeth of these tools strike the work with shocks which are like hammer blows, and those blows can come at the rate of hundreds a second Results might be loosened bolts and nuts, unbearable noises, quickly worn or "peened down" bearings, and plenty of other troubles But with each blow individual members of power transmission sequences stretch slightly, slip a little, compress a few millionths of an inch, bend like springs, or take some other cushioning action The result is that the vibration forces are absorbed by causing the members to do this work and only a slight amount of vibration escapes to do damage elsewhere

Old style belt drives could—and still do—absorb plenty of vibration. The point is that in modern belt drives, as well as in all forms of power transmission, the exact amounts of vibration to be absorbed and the exact methods by which it will be dampened, all are engineered right into the designs of the drives.

And if the duties of the driven machines are changed, the vibration absorbing abilities of the power transmission can be changed too One ship-

yard put some quick-acting, highly elastic belts into the power transmission sequence which took power from the motors to the points of work on drill presses, and found that the production rates could be upped by more than 10 percent, with longer drill life than ever had been obtained in its experience.

On heavy shock loads the power transmission also takes the rap. A saw may abruptly run into a hard knot, a punch press deliver its flywheel force to the heaviest part of its cycle, the parts inside of a tumbling barrel all suddenly bunch up and fall so that their whole weight is thrown against the direction of the barrel's rotation, and so on. When these things happen, the entire machine could be affected as if it had been struck by a giant hammer. But the power transmission sequence is designed with just these shocks in view Its members stretch, slip, bend, and compress just as they would for vibrational loads, the only difference being that their action is slower and the amount of "give" generally is greater.

SHOCK COMPENSATION—Here again the action has been deliberately engineered; engineered as only modern power transmission permits it to be. For slight shock loads the transmission may refuse to compensate more than an infinitesimal amount, rather being designed to force the tools to ignore the shock and get on with their work. But at an exactly calculated amount of shock the transmission members take their cushioning action, save the machine and its tools, give the motor the little extra time it needs to pick up the added load and get the machine back to smooth functioning

Electricity would be far more hazardous than it is if power transmission sequences were not designed to help in the control of it The power transmission can insulate; prevent stray or leaking currents from motors from getting at the machines. Flexible couplings between motors and gear reducers, chain drives, and so on, are made with members which are excellent insulators. Nearly all belts are either excellent insulators or at least very poor conductors.

Power transmission can be an excellent conductor, too, to take static electricity or vagrant currents away from fire-dangerous materials. Rubber belts, for example, can be made into excellent conductors Originally developed to dissipate harmlessly the static electricity in powder mills, these belts now are used in flour mills (flour can go off like gunpowder if ignited while mixed with just enough air) and to furnish similar protection wherever flammable gases or vapors are found. In these ways power transmission joins non-sparking wrenches and static-conducting floors to bring safety to processes which otherwise would be terribly dangerous.

One of the greatest advances in power transmission is its ability to protect itself against its own former enemies.

The fact that modern transmission systems can be encased or enclosed, whereas many of the older ones had to be left exposed so they could be watched for wear and defects, is a great help in protection.

Chain drives, gear trains, and others which need lubrication, often are enclosed. At high speeds they could not be lubricated properly if left exposed, the lubricant would fly too far and do too much damage But, enclosed, these drives may work at such loads and speeds that their casings become too hot to be touched by the bare hands—the heat coming mostly from fluid friction within the lubricant itself. Yet with modern metals and the accuracies possible with them, these drives take such conditions and keep on going for years. Naturally, they have far more capacity for the same size or bulk than had old time drives.

Material	Power Constant
SAE 1010 —1025	6
SAE 1030 —1095	8
SAE 1112 —1120	6
SAE X1314—X1340	6
SAE T1330—T1350	9
SAE 2015 —2320	7
SAE 2330 —2350	9
SAE 3115 —3130	8
SAE 3135 —3450	9
SAE 4130 —4820	9
SAE 5120 —5210	10
SAE 6115 —6195	10
Bronze (Hard)	10
Bronze (Soft)	4
Aluminum Castings	3
Aluminum Bar	4
Copper	4
Cast Steel	9
Cast Iron (Hard)	4
Cast Iron (Medium)	3
Cast Iron (Soft)	3
(Alloy) Cast Iron (Hard)	4
(Alloy) Cast Iron (Medium)	3
(Alloy) Cast Iron (Soft)	3
Malleable Iron (Hard)	5
Malleable Iron (Medium)	4
Malleable Iron (Soft)	3
Brass (Hard)	10
Brass (Soft)	4

Courtesy *Mill and Factory*

Use the simple formula in the text, apply these constants, and metal cutting power requirements are known

Enclosures protect the power transmission members against dust, chemical fumes, water, moisture, oil splashed from machines, and plenty of other enemies which used to add large figures in plant maintenance bills. And where enclosure is not practical, a host of special materials have been used to withstand whatever conditions are found. Belts, for example, once were made slippery and short-lived by oil; now they are impregnated with Neoprene and will stand up indefinitely. Gears are made of special materials to run in acid baths. Stainless steel, Monel, all sorts of corrosion-resistant materials are employed.

Perhaps the greatest advance in power transmission has been in the controllability of speeds at the work points.

A few short years ago, the machine operator had at the most two or three speeds to apply to his tools, and he had to do what he could with them. Now he is more likely to have a high limit and a low limit, but between those two his choices are infinite. The speed of an entire bakery production line or of any machine on it can be changed as varying weather changes the behavior of the flour A brass mill, a paper mill, or a chemicals plant will have speed changing power transmissions from end to end.

Henry Ford is quoted as saying "A machine is a device for submitting power to the control of a man." Modern power transmission does that so much better than it ever has been done before that the ability of men to control mechanical power is becoming the only problem which gives machine designers no headaches at all

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BETTER PUTTY

Is Result of Aircraft Needs

EVEN as industry produces higher accuracies in all assemblies, tighter joints and smoother surfaces, so that far less putty may be needed, research comes back with puttys which are more flexible, more adhesive, and will stand up under greater strains.

Some of the most advanced puttys were specially developed to fill indentations on aircraft wings and bodies and produce more aerodynamically perfect surfaces. Puttys which will take the abuse that warplane service gives them, will solve many problems of factory maintenance and repair

MORE MARKINGS

Graduated Scales Increasing On Machine Tools

A WAR-BORN stunt which promises to carry over into the post-war designs of machine tools is putting more graduated scales on more control parts

Much of this has come from the more complete guarding of moving parts necessary for women employees. The shield which prevented cutting oil from splashing and eliminated the flying of hot chips toward the operator, often would cover up the scale which had to be read to operate the machine.

Scales accordingly were scribed on the rims of hand wheels, along cross slides, on other controls. Supervisors soon found that these scales helped in the instruction of green hands. Then it was noticed that old time machine set-up men used the new scales in preference to the old for much of their work—the new scales were in positions easier to see.

Much of this development is still in the "kink" stage—shops are working it out on their own production-line machines. But the machine-tool makers are watching closely, and the best the kinks will find their way into nal tool designs.

Petroleum s 'Big Three'

Basic Processes Which Have Been Developed for Production of High-Octane Gasoline are Certain to be Turned to New Uses. Plastics, Perfumes, and Insecticides Are Only a Few of the Materials Which May Someday be Produced by One or More of the New Catalytic Processes

By F. J VAN ANTWERPEN
Associate Editor, *Industrial and Engineering Chemistry*

Out of the mighty program of the United Nations for producing high-octane aviation gasoline will come many new methods and processes that will serve all industry well in the years to follow. War-time need has speeded petroleum research and output What might normally have been accomplished in years of hard work, the investment of "patient money" in a comprehensive investigation of basic problems has succeeded in doing in a short space of time. Seldom has any industry increased production facilities as rapidly as have the petroleum producers in recent years.

From this envious period of expansion have come new chemical tools for America. Three important basic operations, new and potent, are almost certain to be retained and expanded to new uses when peace again returns. These processes are fluid catalytic cracking, Thermofor catalytic cracking, and hydrogen fluoride alkylation.

The fluid catalyst cracking process is one of our most important catalytic processes for making high-test fuel. It might be noted that all three processes mentioned above are catalytic in nature, for the chemist of today has made such precise investigations into the nature of catalysis that he can formulate and produce mixtures of chemicals that will catalyze the most difficult of reactions. This is also the case with the fluid catalyst which, incidentally, is not a fluid, but a powder. It is such a finely divided powder, however, that it resembles a fluid; it pours easily, and when gas is passed through a bed of the catalyst, it bubbles and moves much as a liquid might.

The process was developed by the chemists of the Standard Oil Company (New Jersey), as a peace-time expedient for the improvement of motor fuel However, its easily recognized importance made for a rapid expansion when the need for aviation gasoline became acute

After laboratory work was completed, Standard proceeded with the construction of a pilot plant which had a capacity of 100 barrels of gasoline a day. This pilot plant, built to obtain data to design a large plant, cost approximately $400,000 The first commercial sized unit was begun in 1940 and was finished in 1942. The commercial installations are huge, towering some 280 feet. Gasoline made by the fluid method is reported to be above 92 octane.

Courtesy Standard Oil Company (New Jersey)
Control room of a fluid catalyst cracking plant

The application of the fluid technique to the petroleum industry holds promise for other uses. In practice, the catalyst is blown by a gas or air stream through processing apparatus, and at certain points the catalyst may either be regenerated, or it may be drawn off and replaced by fresh catalyst. The chemists, in working out this process, made use of the gas lift principle in which a falling stream of solid may be kept in approximately the same place by an upflowing, powerful stream of gas. Another way of illustrating this is to imagine yourself walking down an ascending escalator and staying at the same height from the ground because of the two opposing motions. Imagine now that the escalator is speeded up. Theoretically a point is reached at which, no matter how fast you try to run downstairs, you will be carried to the top despite your exertion. So it is with the gas carrying the catalyst powder—by speeding the gas the catalyst may be transferred to another point in the system. The opposite effect is also possible, and the catalyst can be settled by decreasing the gas velocity. The important feature pointed out here is the controllability the technique gives over catalyst rise, fall, or transportation.

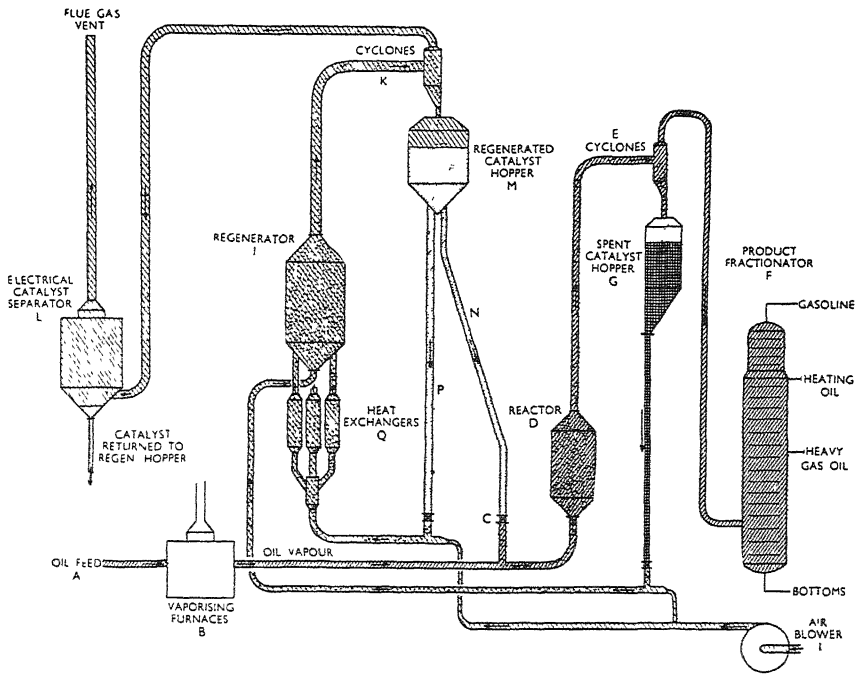
In petroleum cracking by the fluid process, oil is vaporized by heat and forced through pipes to a huge cracking reactor where the actual chemical change occurs. The catalyst is drawn into the oil-gas stream just before the petroleum gas enters the reaction chamber. It is drawn from a standpipe filled with regenerated catalyst. From the reaction chamber the mixture of cracked oil products and catalyst flows through cyclone separators where the powder is collected. The petroleum gas passes on to regular separation equipment found in petroleum refineries where gasoline

fractions are recovered, but the fluid powder flows down a standpipe, and at the bottom of the pipe it is picked up and carried along by a blast of air. The air moves the catalyst to regeneration chambers where coke, deposited on the catalyst during the cracking process, is burned off. From the regenerator the catalyst again passes to another cyclone separator where it is removed from the air (now flue gas) stream and returns to the standpipe for injection, as fresh catalyst, into the oil stream. Thus the cycle is completed, and nowhere has production been halted The process is continuous and the complete transfer of catalyst has been accomplished by moving streams of gas or air. This is a unique process and affords control of heat, density of catalyst, and ease of catalyst transportation, never before obtained in chemical processes.

Thus, concerning the density of catalyst, the inventors of the process state that it has been possible, through extensive investigation of the properties of systems of solids and air, to so adjust velocities of gas as to create points in the process where there were high concentrations of solids The densities which can be attained are functions of the gas velocity, particle size, solid feed rates, and composition.

HEAT CONTROL—Because of the high turbulence involved, the temperature in the various reaction and regenerating chambers will not vary more than 5 degrees, Fahrenheit, from top to bottom. This is an achievement of note, for in burning off the coke in a typical commercial unit, the heat liberated will be 120,000,000 Btu per hour. One hundred and twenty million Btu is equivalent to five tons of anthracite coal or about 900 gallons of fuel oil—about half your winter fuel requirements—and this heat energy is released every hour with a variation in temperature throughout the whole mass of less than 5 degrees, Fahrenheit.

FLUID CATALYST CRACKING PLANT



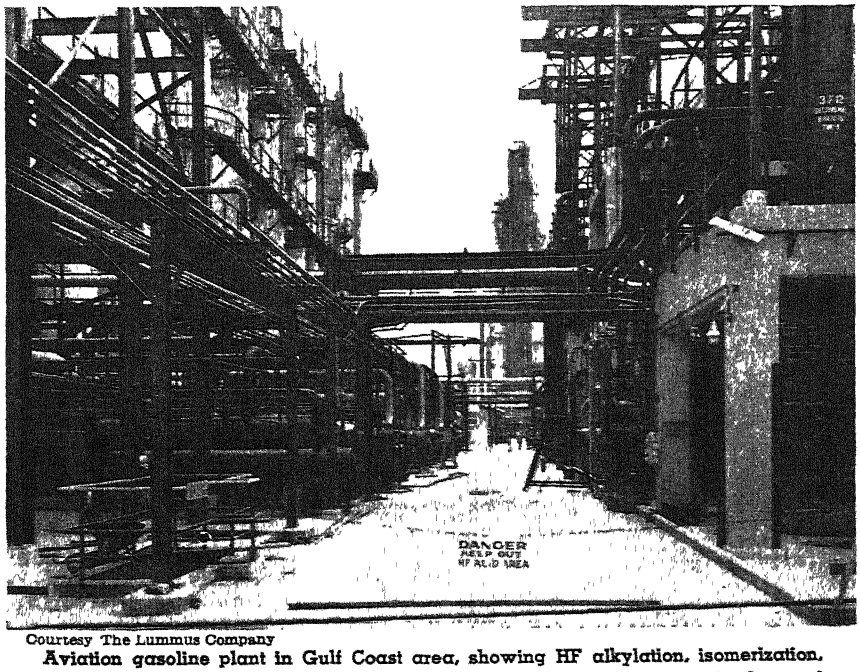
Flow of catalyst and gases in a fluid catalyst cracking plant of Standard Oil Company (New Jersey). Beyond point *C* the powdered catalyst, created by the oil vapor, flows in a manner very similar to liquid flow. Air is used to carry the spent catalyst to the regenerator chamber, *J*, where deposits on the catalyst are burned off. The catalyst then is returned to the hopper *M*, for recirculation

Mechanically speaking, the fluid processing technique is essentially the transportation of a solid much in the same manner in which liquids themselves are handled. There are many more fields of industry which will benefit from this development. It is thought that it might be applied to organic chemical reactions which give off quantities of heat, and in which control of temperature is extremely important. The principle might also be applied in metallurgical processes for reducing ores, and to numerous other types of reactions involving control of gases, vapors, or solids.

The operation of these plants is entirely automatic—controlled by instruments which respond to and control conditions existing in the processing unit.

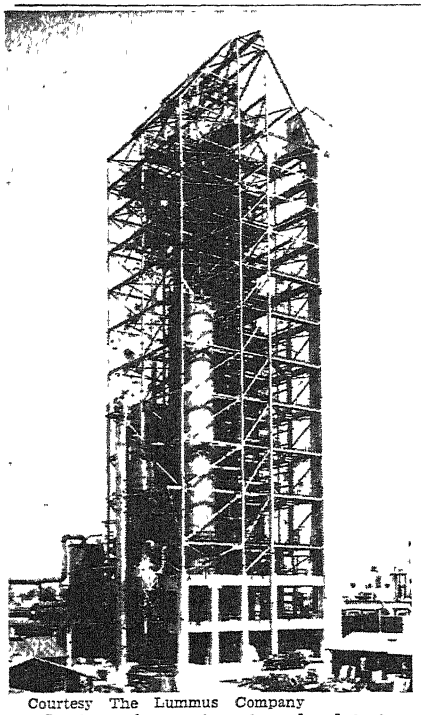
THERMOFOR CATALYTIC CRACKING—The second important tool to come out of war-speeded research is Thermofor catalytic cracking. Technically the process is similar to the fluid and other catalytic processes, except that the catalyst is not a powder but a small bead or pellet, similar to the pellets used in the older Houdry catalytic units. The Thermofor is a continuous system, just as the fluid catalytic process is a continuous system; both are to be distinguished from the Houdry process which is a stationary catalytic bed type The bed of catalyst moves right through a reaction zone, in which vaporized petroleum is changed to aviation fuel, through an air burning regenerating zone, and back again to do more work as an active catalyst.

This particular development is the work of the Socony Vacuum Oil Company and resulted from research done in 1939 in burning coke out of the clay used in filtering lubricating oils. The commercial equipment is tall—some 200 feet high, and this is explained by the fact that equipment is mounted on top of the piece next in the processing line. The reactor, in which the gas meets the catalyst, is 30 feet high. Surmounting this is a catalyst feed leg —70 feet high—which delivers the catalyst to the reaction chamber. The feed leg is fed by a hopper for catalyst storage, and still above the hopper is the discharge end of the elevator which delivers the regenerated catalyst to the storage hopper. After passing through the reaction chamber, a bucket



Courtesy The Lummus Company

Aviation gasoline plant in Gulf Coast area, showing HF alkylation, isomerization, and gas plant areas, with a Thermofor catalytic cracking unit in background



Courtesy The Lummus Company

Section of a unit using the latest Thermofor bead synthetic catalyst

type elevator picks up the catalyst and delivers the spent catalyst, (so called because it is covered with carbon and cannot react properly with the petroleum gases), to the top of a regenerating unit in which the coke or carbon is burned out. The intense heat generated in this portion of the system is removed by water cooling systems which generate immense quantities of steam. The catalyst tumbles slowly through the regenerator and is purged of all carbon. At the bottom of the chamber an elevator, bucket type, collects the catalyst and returns it to the top of the unit to the storage hopper as active catalyst—and the cycle begins again.

Though this may seem a simple operation, it is in reality possible only because many complex mechanical problems were solved. One of the tough operating stumbling blocks was overcome by the construction of a special bucket which can operate at high temperature.

Gasoline of fairly high octane is realized by this process, and though Thermofor's future lies mostly in the petroleum industry, chemical engineering has a new tool for catalytic operations requiring solid catalysts Adaptation will be easily accomplished and one of its very important advantages is its simplicity of operation

HYDROGEN FLUORIDE ALKYLATION—Not the whole importance of the use of hydrofluoric acid for alkylation lies in the fact that it represents the use of a highly dangerous, corrosive chemical in commercial quantities. Prior to its adaptation to the petroleum field, its application lay mostly in the etching of glass. Now, freed from a typed part in the industrial drama, it may rise to leading roles in organic chemistry.

Briefly explained, alkylation, in chemical language, is the combination of isoparaffins and olefins to give branched chain chemical compounds of higher molecular weight This means, really, the combination of two hydrocarbons to form iso-octane—which is commonly called 100-octane gasoline In the preparation of 2,2,4,-trimethyl pentane, which also is 100-octane gasoline, isobutane and propylene are combined—and hydrofluoric acid is one of the catalysts that may be used in this operation This difficult chemical operation is being done on a huge scale today for the war effort—but there is the strong possibility that other reactions made possible by this acid will, in the future, form the basis for other chemical enterprises

Hydrofluoric acid, HF, is a dangerous material It requires constant supervision, the best design, and the most corrosion-resistant materials to keep it within bounds. Bad burns are caused to personnel who are unfortunate enough to come in contact with the acid, but under properly supervised work such accidents may be prevented Other acids, notably sulfuric acid, can be used for alkylation reactions, but the power of HF is such that much more is expected of it It causes, with ease, reactions which, under ordinary circumstances, would never occur, or which occur with the greatest difficulty. HF is the newest wonder-working tool of industrial chemistry—a tool which was constructed during the days of peaceful research, but one which was sharpened in the crisis of war

Someday the citizens of this country will blandly use plastics, gasoline, perhaps perfumes and insecticides, all made through the use of catalysts of one form or another. Today our aviators are winning air battles through gasoline made powerful through the process of catalyzation. Such is the power of chemistry

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ION EXCHANGERS

Find New Uses in Producing Substantially Pure Solutions

Ion exchangers, used extensively in the softening and demineralization of water, have a new chemical use. John W. Ryznar, of the National Aluminate Corporation, in a report to the American Chemical Society, tells of using a cation exchanger to remove the sodium from a solution of sodium silicate. The resulting product was a pure silicic acid substantially free from electrolytes.

The process may be used for the exchange of other minerals; for, in addition to sodium ions, calcium, magnesium, and aluminum may be removed and a hydrogen ion substituted for them.

Reversing the process, anions can be exchanged also through the use of an anion exchange material. Thus a solution of aluminum chloride can be changed to aluminum hydroxide by the simple expedient of passing the chloride through a bed of the chemical exchanger.

Solutions made in this manner have high purity. Tungstic oxide sols containing 99 percent tungstic acid and 0 5 percent sodium oxide have been formed by this method, the report states.

CONTINUOUS POLYMERIZATION

May Almost Double Capacity of Rubber Plants in United States

The potential production of 1,338,000 long tons of rubber from the originally designed capacity of our rubber plants of 735,000 long tons is fully possible if a new discovery for continuous polymerization is utilized.

The new rubber technique is the invention of chemists and engineers of the Goodyear Tire and Rubber Company Prior to the development of this process, which represents the culmination of two and a half years of research and experimentation, the limiting factor in the total capacity of synthetic rubber plants was the batch polymerization of the buna-S latex

The possible production of 1,338,000 long tons is larger that the total pre-war world consumption of rubber. The additional investment involved to install the process in rubber plants is only about 1 percent of the original capital cost

POST-WAR RUBBER COSTS

Will be Lowered by Petroleum-Alcohol Competition

Post-war prices of rubber have been estimated by the Office of the Rubber Director According to the information released, actual cost at present of buna-S rubber is 12 2 cents a pound and butadiene and styrene are 8 cents and 7 cents respectively. Post-war cost of buna-S will be 10.7 cents with butadiene at 7 cents and styrene at 5 cents a pound These figures do not include amortization, sales expense, profit, or interest on investment.

Plantation rubber during the period 1935-1938 was about 10 cents a pound Neoprene rubber is said to cost 24 cents at present with a future cost of 19 cents possible. Butyl rubber is quoted at 21½ cents now, with a 10 to 14 cent spread for the future

NEW SLIDE RULE

Simplifies Vapor-Pressure Calculations

A vapor-pressure slide rule, useful to chemists and chemical engineers using distillation processes and enabling vaporization calculations to be performed in a fraction of the time usually required, has recently been invented. The critical point is marked, and the latent heat of vaporization is given on another scale. The slide rule performs gas law calculations directly, and conversions of temperature, pressure, and heat units are shown. Calculations are accurate to one degree, Centigrade.

The vapor pressure curve for any liquid can be estimated from a single vapor pressure value—for example, the boiling point.

Steel Treating

Wartime Advances in the Heat Treatment of Munition Steel Not Only Assure Higher Quality Steel Parts at Lower Cost for Peace-Time Products, but Will be Responsible for Widespread Changes in the Design and Performance of Lighter or More Powerful Engines and Machines

HEAT treatment, as recently as 25 years ago a combination of blacksmithing and black magic, is today our most "scientific" metal-working process and is the chief reason why American munitions and machines are individually the world's most powerful

There are still heat treaters who, by dint of years of painfully acquired experience, are able to harden a familiar part or tool by heating it (one at a time) to a temperature that is estimated with varying degrees of precision from its color when hot, holding it at temperature for "one hour per inch of cross-section," dunking it in oil, water, or brine and then tempering by heating until the steel turns blue or straw or some other predetermined hue known to represent the "temper" sought

But the modern shop operating on a high-production basis to stiff quality and precision requirements employs all the known devices that the metallurgical, electrical, and mechanical sciences have most recently evolved automatic-temperature-controlled and closely-timed cycles and processes; special treatments that make the necessary transformation painless instead of violent; electrical, electronic, and direct-flame processes that permit rapid, versatile, and *selective* heating; non-reacting gas atmospheres that keep the steel bright and unchanged chemically although heated white-hot; continuous-furnace designs that substitute space for time, and mechanisms that automatically raise, lower, start, stop, transport, straighten, heat, cool, drench, or dry the steel; quench-oil or -water systems that scientifically cool, clean, and circulate the quenching liquid, and so on.

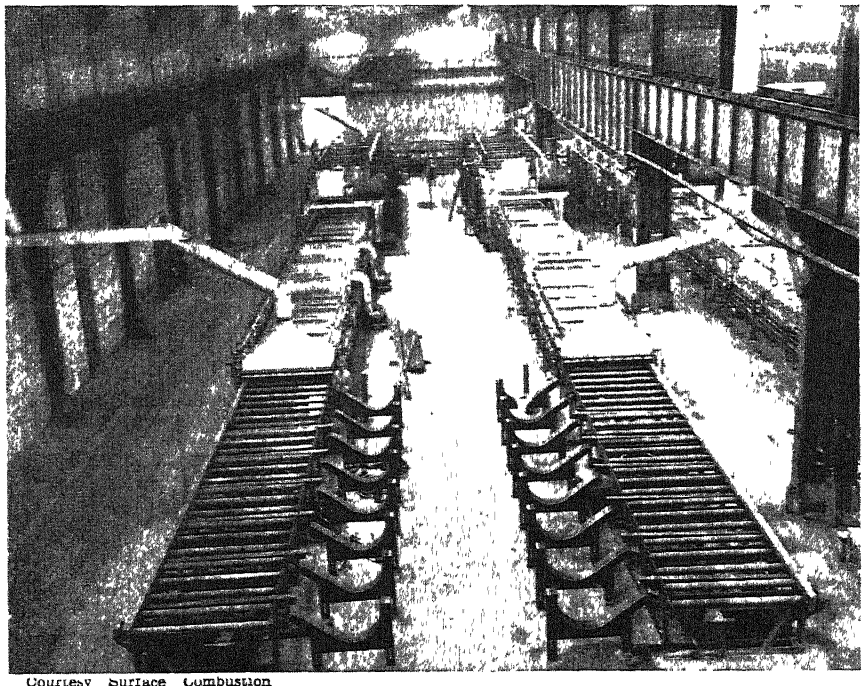
In the more precise lexicon of the metallurgist the most important of these time-saving, quality-insuring, and design-simplifying methods or processes are known as automatic or continuous furnaces, isothermal (constant temperature) heat treatment, induction hardening, controlled-atmosphere systems, and regulated quenches. All are outstanding as processing developments but in addition most of them have special significance for the design engineer.

For example, if you were a machine designer blueprinting a reciprocating engine and its parts, you would be enormously grateful for some means of obtaining complicated crankshafts that could be made of inexpensive low-alloy or plain carbon steels, which could be machined easily and *then* heat treated, and which would not thereby be so warped as to be unacceptable without further machining

INDUCTION AND FLAME HARDENING—That is exactly what induction and flame hardening frequently make possible, because they provide a means of selectively heating and hardening just the wearing surface of locally restricted regions (crankshaft journals, for example) without the cost and time for, and the warping always associated with, heating and quenching the entire piece of metal. Internal stresses and the danger of cracking or of early failure in service are also avoided by these surface-hardening methods; in fact, induction or flame-heating may be employed to soften or stress-relieve locations or areas already overstressed mechanically.

Several types of induction heating equipment have been highly developed in recent months In all of them, of course, the workpiece is placed inside a conductor coil carrying high-frequency (usually from 9600 up to several million cycles) alternating current. The reversals induce current flow and therefore heat in the surface of the work; the higher the frequency used, the thinner is the surface-skin that is so heated. The time required for each operation is, of course, a function of the power applied, the size of the part and other factors, but with induction heating the time is so short—often a fraction of a second up to a few seconds—that production rates are startling and in addition the work is at temperature too short a time to be more than slightly darkened by oxidation.

Many units now in use are specially designed, self-contained, automatically timed machines that feed, heat, spray-quench, and eject the parts according to a predetermined cycle with astonishing uniformity of results The electronic tube converters, supplying frequencies of 100,000 up to several million cycles, have enjoyed a wave of war-time publicity and well-deserved technical interest, but the motor-gen-



Courtesy Surface Combustion

Continuous roller hearth furnaces for annealing and normalizing aircraft tubing

erator-powered sets (up to 12,000 cycles) continue to supply a large part of the total power used for induction heating and are responsible for some of the most advanced automatic and continuous jobs. A third type—the spark-gap converter—is an old and popular standby able to do many smaller jobs in extremely versatile fashion.

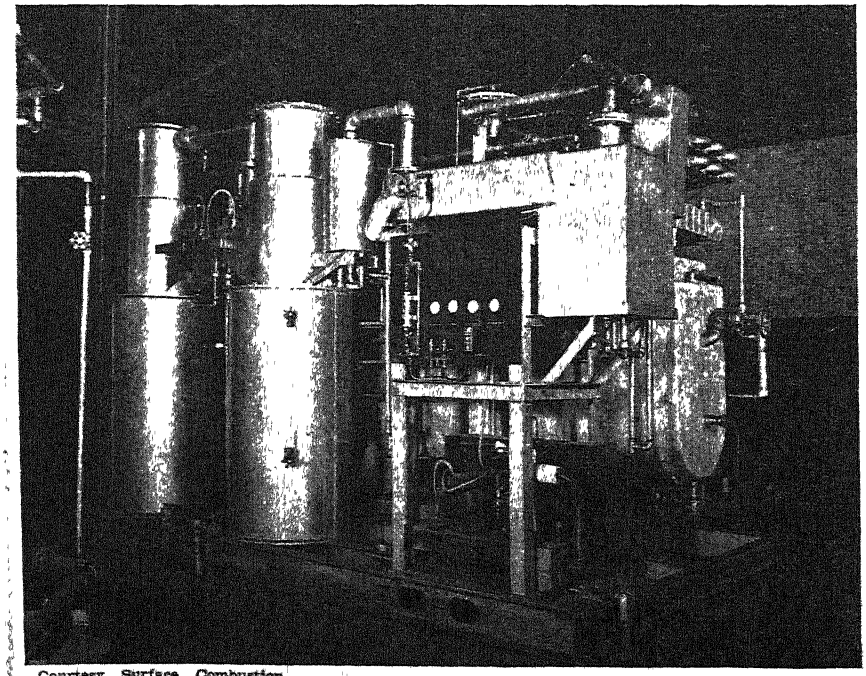
Induction hardening has thoroughly established itself as an ideal method for economically hardening various types of large and small shafts, pins, gears, bearing races, cams, levers, and other machine parts, especially where only the surface is required to be hard The use of the method for the continuous hardening of steel bars was described in Scientific American, October 1944, page 169 One of the war's outstanding uses of induction was for the differential hardening of armor-piercing shot of several sizes.

FLAME LESS EXPENSIVE—Flame hardening (the manual or automatically controlled application of an oxyacetylene flame to the surface of a steel part, followed immediately by a regulated spray of water) has been used for many jobs similar to those on which induction is employed. Flame hardening is not so expensive as induction but it is also less versatile and less adaptable to special shapes and problems—and especially to straight-line continuous production work. Recent flame-hardening trends were highlighted in Scientific American, September 1944, page 103.

A very recent development in gas heat treatment is the ceramic burner, in which pre-mixed gas-air mixtures are combusted at extremely high rates to give an intense, directed, and patterned heat. Heavy steel parts can be brought to temperature and heated throughout in time periods so short as to make a mockery of the old "soak one hour for each inch of thickness" rule (a ceramic-burner-fired furnace of this type can heat an eight-inch steel billet to 1650 degrees, Fahrenheit, throughout in just 14 minutes), and in addition the furnaces can be surprisingly small, according to the usual standards. Finally, the ceramic burners can be shaped or hooked-up in such a way as to heat the surface of steel bars, tubes, or parts with much the same effect as induction, and they are already successfully competing with induction equipment for some surface-heating jobs

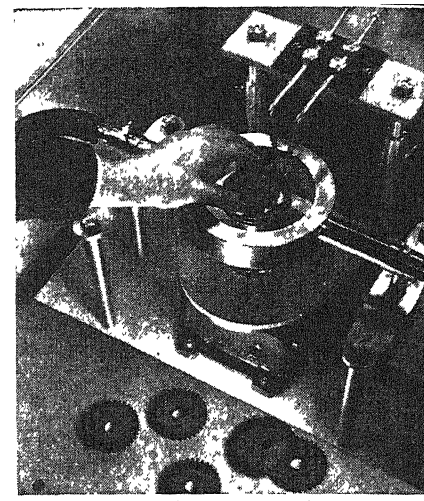
CONSTANT-TEMPERATURE TREATMENTS—Fastest comers of all the heat-treating processes recently have been the isothermal or constant-temperature treatments, which make use of a metallurgical concept formulated less than 15 years ago and only now "catching on" generally. Known as "Martempering," "Austempering," "Interrupted Quenching," and so on, the isothermal treatments are based on the principle that the transformation responsible for the hardening of steel does not necessarily have to be effected by the conventional but often non-uniform and distorting practice of heating to a high temperature, quenching in oil or water, and then reheating to an intermediate temperature, but may instead be carried out by heating to the same high temperature, *quenching into a molten salt or lead bath held at an intermediate temperature,* and then cooling to room temperature.

In the second procedure most of the transformation occurs while the steel part is at a constant temperature, instead of while its temperature is rapidly falling, as in the conventional method; hence all portions of an intricate steel part pass through the volume-changing transformation at approximately the same moment and are not subject to the serious warping that would result if it were quenched-and-tempered.



Courtesy Surface Combustion

A typical controlled-atmosphere generator used in heat treating alloy steel



Courtesy Lepel High Frequency Laboratories, Inc

Set-up for induction hardening of gear teeth. The pedestal on which the gear rests may be revolved to improve the uniformity of heating

The isothermal processes have received special impetus during the emergency because of the necessity of using low-alloy or plain-carbon steels for many parts. Such steels require drastic quenches to harden them properly by conventional means, and the drastic quenches in turn produce prohibitive distortion and even cracking. By using the salt-bath-quenching process superlative physical properties can be obtained, without any warping or cracking.

One outstanding application of isothermal treatment is the hardening of fuses made of S A E. 4140 (chromium-molybdenum) steel. The salt-bath process in one installation (several are in operation) cut the operating time from 1 5 to 3 hours by the conventional method to 40 to 48 minutes by isothermal treatment. This unit handles over 165,000 pairs of fuse parts per month and, despite rigid government inspection, has yet to have a single lot rejected because of heat treatment

The rise of this process has further extended the use of molten salt baths as heat treating media, and especially of electrically heated salt-bath furnace equipment, which lends itself admirably to the quick, clean, mass-production requirements of such work. The electrically heated salt baths had already earned a special place in the hearts of war production men through their applications to the rapid, minimum-decarburization hardening of high-speed steel, to the case-hardening of steel, and to the neutral-hardening of many parts; two notable special cases have been the successful use of salt-bath methods for the differential hardening of armor-piercing shot (in competition with induction) and for the simultaneous brazing and carburizing of steel assemblies.

CONTROLLED ATMOSPHERE FURNACES—The virtual revolution in heat treating represented by the now wide-spread use of controlled atmospheres is of as much interest to engineers and designers as are the possibilities in induction heating, previously outlined. The use

of controlled atmospheres can mean more reliable or smaller, stronger, and cheaper parts, and ultimately lighter or more powerful engines and machines

It is as simple as this When steel is heated, either for rolling, forging, annealing, or hardening, in the presence of air or oxygen it oxidizes and in many cases becomes decarburized—that is, some or all of the surface-carbon content is lost. This low-carbon skin remains soft instead of developing the desired hardness when the piece is subsequently heat treated and as a result the part has lower hardness, lower tensile strength, and particularly lower fatigue strength (resistance to failure in vibrating or repeated stresses). Extra thickness must therefore be provided either to bulk up the part and enhance its strength or to permit the machining away of the soft decarburized surface. Sometimes the part before machining off the soft layer is weaker than the same (but thinner) part after the decarburized skin has been removed.

Machining for this purpose alone is expensive and wasteful of metal The designer would much prefer to manufacture to something very near final size and using steel analyses that involve no wasteful incorporation of alloys just to correct for surface weakness. His end result would thus be smaller, lighter, and stronger parts able to operate at higher stresses and loads, in keeping with the general trend toward faster, more powerful machines and engines.

Controlled atmospheres are now making all this possible. If during its heating at the mill and its subsequent hardening the steel is surrounded in the furnace by a special non-oxidizing gas atmosphere that is also *non-decarburizing* to the steel, it will come out bright and hard and no extra thickness or alloy need be provided.

Several atmospheres are used industrially for this purpose, many of them designed specifically for a particular set of steel composition-temperature circumstances. They represent today a sizeable portion of the heat-treating equipment industry; some atmosphere generators are sold separately from the furnace while others are designed into the original heat-treating system and are an integral part of it.

PROCESS DESIGN—Mechanization has made heat treatment a mass production operation in many shops that once considered it a hand-craft process. Conveyorized systems embodying special heat resistant alloy parts take the work into and out of furnaces, dump them into quench tanks, move basket-containers out of the tanks and into cleaning systems, and so on. Elevating mechanisms carry the work from one level to another where advantageous or necessary.

Many units now incorporate zone control, the furnace being designed with three or four different-temperature zones; the work moves continuously and progressively, for example, through a preheating zone, a soaking zone, and a controlled cooling zone, all at accurately regulated temperatures, with the time in each zone controlled by the physical length of the zone.

"Fancy" quenches of various types, many employing mechanical systems to keep the hot part from warping during the drastic quenching period, are increasingly used. In fact, the importance of quenching as a major factor in both the efficiency of the heat-treating operation and the success of the entire part-manufacturing process is just starting to receive general recognition

Better quenching oils are now available and temperature-controlled, often refrigerated, quench tanks are found in the more advanced shops Water quenching of plain carbon and low-alloy steels can be increasingly used in place of oil quenching of more expensive high-alloy steels because of efficient fluid-circulating or part-agitating systems and the chemical treatment of quenching water to provide instantaneous and uniform heat-extracting behavior and thus to avoid soft spots or cracking.

But the broadest and therefore the most significant heat-treating development has been the tremendous increase in the use of heat treating itself Steel armor-plate castings, for example, are now liquid-quenched and tempered to produce the necessary ballistic resistance, instead of just being made thicker or doped up with alloys as formerly. In the future, many cast and wrought steel products will similarly be heat treated with considerable improvement in quality and performance of the product and saving in weight or alloy-cost as well

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CERIUM IN ALLOYS

Improves Mechanical Properties And Casting Behavior

EXTENSIVE research by Russian metallurgists has established the fact that incorporation of 0 3 to 0 35 percent cerium in aluminum alloys results in substantial improvement in both mechanical properties and casting behavior.

In aluminum-silicon-copper casting alloys, for example, tensile strengths were 20 to 30 percent higher when cerium was present than with cerium-free alloys, and elongations increased more than 15 percent. Rejections of pistons for cracking, unsoundness, blowholes, and so on were considerably reduced when cerium was present

NAVY SMOKESTACKS

Have Been Redesigned For Mass Production

AN interesting example of the skill and ingenuity of modern stamping engineers is the redesigned naval smokepipe. These smokestacks usually consist of an outer and an inner pipe with an air space between. Before the war the conventional method of building them was to use the inner pipe as the strength member and the outer casing as the cover.

Lightness of weight is essential, strength must be maintained, corrosion should be resisted, and design must be such as to reduce overhaul time to a minimum. It was found that molybdenum-bearing stainless steel gave the greatest resistance to corrosion for this use and was adopted for the inner pipe, with ordinary "18 and 8" stainless used for the casing.

In the redesign the inner pipe is made the strength member for only three feet above its foundation. At that point the stresses are transferred through intercostals to the outer casing, which then becomes the strength member The inner casing above the transfer point is only 0.040 inch thick and is sectionalized to permit removal of an upper section without disturbing these below it.

This redesigned smokepipe not only met all naval requirements but speeded production

SPONGE IRON

Now Being Experimentally Produced in the United States

SPONGE iron—iron produced directly from ore by reducing the latter in the solid state, without smelting—has not previously been manufactured in this country, although a moderate tonnage had always been imported from Sweden and used as an ingredient of certain high quality steels. Recently there has been considerable interest in the possibility of making sponge iron from low-grade ore on a large enough scale to compete with blast furnace pig iron as a raw material for general steel making.

Despite the counsel of experienced metallurgists, that American ores are just not suited to the economical production of sponge iron that can efficiently be used for steelmaking, several proposals have been kicking around Washington and elsewhere, designed to set up numerous direct-reduction sponge-iron plants and eventually to circumvent on a large scale the blast furnace stage of iron- and steel-making. Most of them smell slightly of politics but a few that are based on fairly large units using specially favorable ores have possible merit.

At least one plant is already in operation—a Defense Plant Corporation plant operated by Republic Steel Company at Warren, Ohio. The ore used is an Adirondack magnetite and the process involves reduction of the ore by hydrogen at 1200 to 1300 degrees, Fahrenheit, in a Herreshoff furnace, in which the hot gas is bubbled up through the fine ore on a bottom hearth and moves upward, over, and around other hearths at various levels while ore drops downward from hearth to hearth.

The projected capacity of this plant is 100 tons a day. The hydrogen is obtained from coke oven gas, the total amount of gas handled being roughly equal to that in a blast furnace.

Engineers and politicians alike are watching the plant's performance with great interest, although their conclusions may be quite different.

A Miracle Of Production

Under Vastly Increased Demand, Aircraft Engine Builders Stepped Up Production Squarely in the Face of a Diminishing Supply of Skilled Labor. One Manufacturer's Methods, Which Successfully Accomplished the Impossible, Involved Many Special-Purpose, High-Production Tools

ONE OF the marvels of American effort in the present war has been the enormous increase in the production of powerful aircraft engines, in spite of shortages of skilled manpower. The even greater wonder is that this increase in production was not achieved by mere multiplication of hands at work and of standard machine tools on the floors of our factories. It was achieved rather by intelligent planning; by almost revolutionary changes in the design of machine tools so that their functions and capacity were multiplied many times while the skill required to operate them grew less; and by the careful training of novice operators, women for the most part. The Wright Aeronautical Corporation has, perhaps, achieved the most signal success in this aspect of the war effort, and this article is restricted to a study of the work of Wright Aeronautical in building the huge Cyclone engines which equip our bombers and many other military airplanes in all parts of the world. It is not necessary to emphasize what the availability of vast numbers of engines has meant to America in the war. But it is proper to emphasize the lessons which a production-minded nation can draw from this supreme effort in production.

It was the construction of special-purpose, high-production machine tools that has been, more than any other factor, responsible for the tremendous increase in the production of aircraft engines. The first cost of these machines is high, but in most cases the cost has turned out to be lower than the cost of a large number of standard machines required to give equal output. And in all cases the actual production costs have been far lower than the costs which resulted from earlier methods.

Far more important than any reduction in costs has been the enormous savings effected in man-power and production hours. For example, the Greenlee Automatic Transfer Machine used in the manufacture of cylinder heads took the place of 42 standard machines which would have required the employment of 107 skilled and semi-skilled workers per day. Only eight operators per day, working only one shift, are needed for the Greenlee. Since the work of these operators consists mainly of loading and unloading, with the accurate placing of parts and all the rest up to the machine, they are usually women who have been given only a few days' training. One set-up man is the only skilled operator needed to keep the machine running. Thus, a direct saving of 99 persons was effected by the introduction of this single tool.

Figure 1: Supercharger sections passing on conveyors through a paint spray room

A subsidiary but still important saving was effected in the construction of these tools In many cases, it took little longer to build the special machine than to build one standard machine With the great reduction in the number of machines to be built, there resulted a formidable decrease in the number of man-hours in building the equipment itself. Moreover, this equipment was so designed that unskilled women could be employed, again saving man-power.

SUBSTITUTE FOR A MAN—In heavy industry, the main objection to female labor has been the lack of physical strength for lifting heavy parts into and out of machines. This was overcome through the installation of mechanical lifting devices such as hand or electric hoists at each machine, or by the use of overhead traveling cranes. Conveyors of both the roller and power types simplified still further the handling of heavy parts for women workers, and also effected enormous savings in floor space by eliminating the usual temporary storage at each machine. Thus, the one Greenlee Transfer Machine, previously mentioned, saved more than 3000 square feet of floor space. The steady flow of parts also saved aisle space, and reduced trucking operations and the number of supervisory personnel.

An engineering or manufacturing effort rarely starts from scratch—nor did this one.

To begin with, the Wright Aeronautical production engineers counted upon and secured the help of a magnificent machine-tool industry, accustomed to meeting the needs of heavy industries such as steel, automobile, Diesel, railroad, and so on After the Wright people decided what they wanted to do, they called in the representatives of the machine-tool industry and secured the most skilled and complete co-operation in the way of special layouts. What was deemed at first impossible merely took a little longer.

Furthermore, the Wright Technical Production Unit had the example and precepts of the automobile industry before it. For years automobiles had been produced in large quantities with

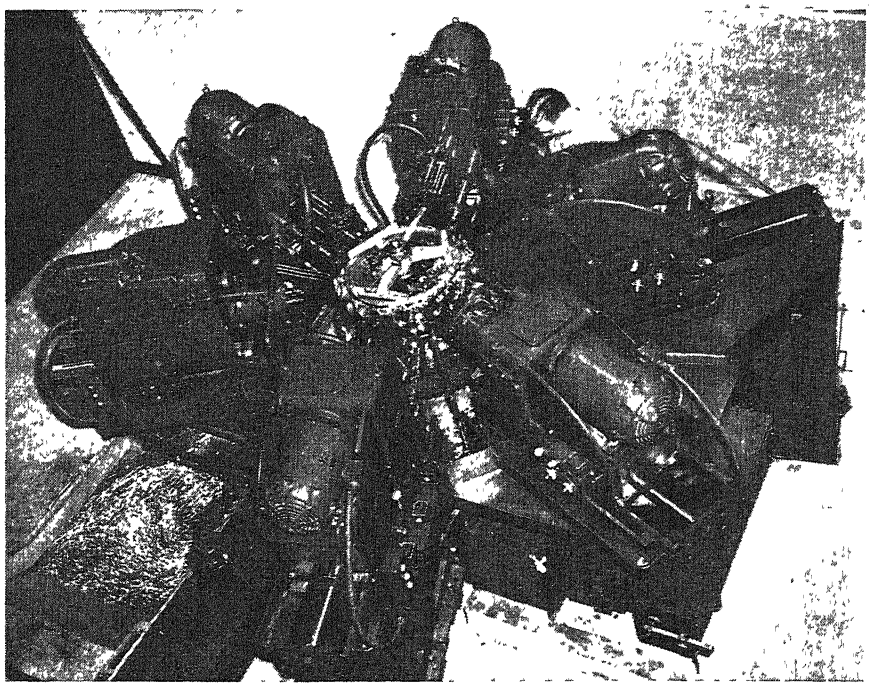

Figure 2: This Greenlee six-way horizontal automatic machine performs a number of simultaneous operations in the front section of a supercharger

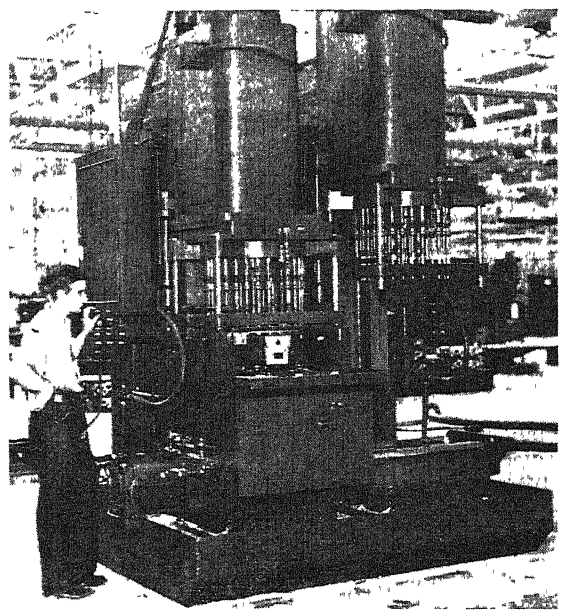

Figure 3: Duplex hydraulic feed Baker drill putting 38 holes in the crankcase nose section of a Cyclone

a high degree of precision whenever necessary The methods which were successfully applied to automotive practices were closely studied and formed the basis for much of the aircraft engine effort The Technical Production Unit, though fully acknowledging its debt to motor-car builders, went much further than to transplant automotive practices into aircraft engine factories. A review of general industrial practice was also made. New equipment was studied, new processes and practices were investigated, and current methods were re-studied. In particular, the conviction that skill would be short led to "automaticity" in the machine tools

SYNTHETIC SKILLS—Just because multiple operation combined with a minimum of skill was the goal, worker training was not neglected; indeed, it was very effective. Many thousands of men and women were brought into the aircraft industry. In general, the work which the newcomers had to do was different from that which they had done before the work tolerances required had become generally smaller, the finishes better, the care in handling greater, and the inspection methods more complex and more exacting Nevertheless, it was proved that a training program could be devised whereby unskilled men and women could become, in a relatively short time, members in good standing of a team producing the best aircraft engines in the world.

These workers, with specially designed multiple-operation equipment, achieved greater production speed. greater precision, few mistakes, and fewer rejections than at first thought possible. Not only that, but it was shown that, relieved of its physical exertion, women actually liked machine-tool operations better than men.

When the details of machines and processes are considered, there is an embarrassment of riches. It is impossible to describe more than a fraction of the many and remarkable tools and methods, selecting a few striking examples, with the assurance that many others, almost as striking, remain unrevealed

Perhaps the best plan is to concentrate attention on the production of a few representative parts of the famous Wright Cyclone. All comparisons of savings in time and man-power are based, incidentally, on a monthly production of 1000 engines, using a 720-hour month with 20 percent allowance for contingencies, scrap, and set-up.

Of course, no Cyclone would be complete without its supercharger, and the manufacture of the supercharger front section serves to illustrate very well some of the points of this article.

Thus, Figure 1 shows automatic conveyors carrying supercharger sections and other parts through the initial paint spray booths for the priming coat and into the baking ovens. Without any additional handling, the parts then pass through two finishing paint booths and trundle on into the baking ovens

Figure 2 shows a six-way Greenlee horizontal and angular 14-station automatic indexing machine for rough and semi-finish boring, facing, and drilling radial holes in a supercharger front section At the first loading, this machine rough faces and bores 14 intake ports and seven mounting pads, and rough bores three holes in the oil sump pad. This same machine is also used to semi-finish face and bore 14 intake ports, semi-finish bore the seven mounting pads, finish bore three holes in the oil sump pad, drill two holes in each of the seven mounting pads, drill seven holes in the oil sump pad, and drill four holes in each of the two breather pads The Greenlee machine, used in conjunction with an eight-way horizontal and angular 14-station automatic indexing machine, finish reams, chamfers, and taps radial holes in the supercharger front section. The two machines replace four; namely, a radial drill, a radial tapper, vertical mill, and rotary table The two special machines cost $25,400 more, but they saved 276 square feet of area, five handling operations, 17 men, and 121.6 production hours a day.

AND SAVED MONEY—Surely, Figure 3 is another convincing proof of the marvels of modern automatic methods. The duplex hydraulic feed Baker drill is used for drilling 38 holes in the hub and flange of the crankcase nose section. When this operation has been completed, the drill table carrying the part is traversed by power into position under the second head where the holes are reamed The one machine cost $15,000 *less* than three radial drills, and saves 67,414 production hours a day.

Perhaps one of the most remarkable developments of all is in a huge Greenlee automatic transfer machine which drills, reams, counter-sinks and taps all the holes in a Cyclone cylinder head at the rate of one part every 50 seconds. A conveyor at the rear carries the completed parts to the final operations The manufacture of the Cyclone

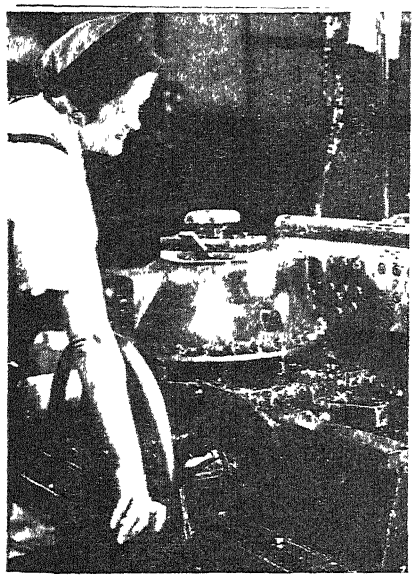

Figure 4: Like it more than men

cylinder head necessitates the performance of a large number of comparatively short operations but, because of the many different angles, the employment of individual jigs and standard tools was the logical procedure. Loading and handling consumed a greater amount of time than the actual machine operations, and this particular part, therefore, offered unusual opportunities for savings through the application of continuous automatic equipment. Experimental work with special multi-spindle machines demonstrated the possibility of retaining the desired accuracy. The development of the transfer machine was responsible for a saving of 3768 square feet, also of 15 handling operations, 99 men, and 789.7 production hours a day, *plus* a saving in cost of equipment of $6234

In Figure 4 Edna Boehmer, a woman evidently at ease in her work, is operating a special horizontal Baker drill equipped with manual index and hydraulic feed. The 15 holes in the governor pad of the nose section are drilled, reamed, and counter-sunk, all in one set-up. On the basis of the 1000 monthly engine production, the Baker drill saved, as compared with the standard radial drill, 12 square feet of floor space, two men, and 19 34 production hours per man. Cost of the machine was $1000 more

LESSONS FOR ALL—There are many lessons to be learned by American industry, and even by the nation as a whole, from this stupendous effort.

Other industries can profit by the experience of Wright Aeronautical. The huge micromatics and other tools developed during the war will serve builders of Diesels, of tanks, of steel rolling mills, of gear manufacturers, of sugar machinery. And even the automobile industry could learn a good deal from this work.

All industry can take this lesson to heart. When seeking to increase production or reduce costs, the solution is not necessarily merely to have more rows of machine tools, more hands at work. The path may be, rather, toward greater skill in the design of the machine-tool equipment, in multiple-operation tools, in more automaticity.

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PROPELLER TESTING

Carried On in Huge Laboratory

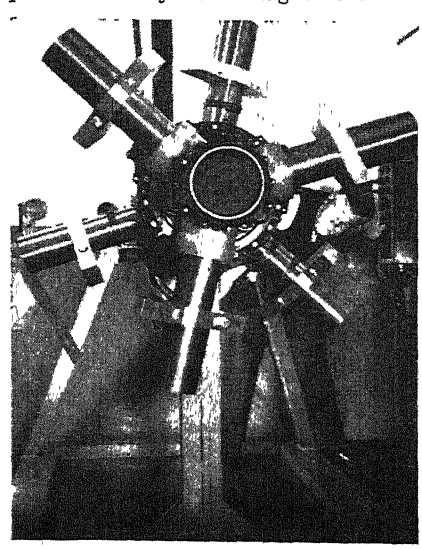
A GIGANTIC propeller laboratory, in which it will be possible to test airscrews up to 30 feet in diameter and air-cooled and liquid-cooled engines of more than 5000 horsepower, has just been completed by the Propeller Division of the Curtiss-Wright Corporation. These dimensions and powers are a little ahead of the practice of today, but they are certain to be attained within a very few years.

There are three characteristics of the propeller, in addition to efficiency and low or moderate weight, which must be determined before it is acceptable—safety, durability, and serviceability. The test cells in the new laboratory will give full information about all three.

The cells are 38 feet square, with honeycombs and other devices to provide uniform air flow. As shown in one of our photographs, a 48-inch jet tube in the upper foreground slides forward to cool the air-cooled engines in operation. In the upper background may be seen the window of the control compartment from which all tests are directed. The tunnel in which the tests are made involves a huge Venturi tube, which is 31 feet in diameter at its narrowest point.

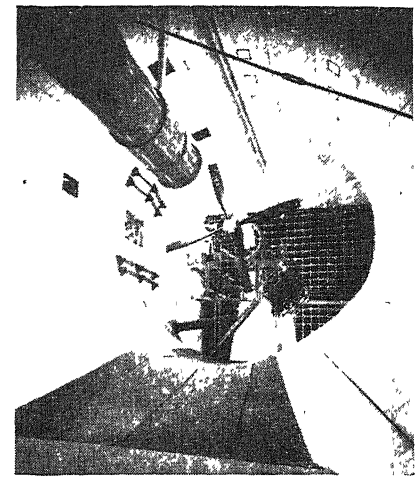
Since control of the engine is an essential part of the propeller tests, engine and propeller are tested simultaneously, and on the instrument panels in the control room all engine and propeller reactions can be charted.

Aircraft people can perhaps say with pride that they have taught other in-



Counterweights on propeller stubs simulate twisting moment under test

dustries the art of large scale industrial research, no matter how complex or expensive. One line of investigation in particular has been pushed to the limit in aviation—the investigation of vibration and of structural endurance Thus



Looking down propeller test cell, with cooling tube at the upper left

in one test of propeller blade stubs counterweights are used to simulate the twisting moment ordinarily exerted upon the power unit by the electric propellers while in actual operation. With these counterweights doing their utmost, the propellers are subjected to well beyond their maximum capacity for hours at a time.

BRITISH COMPETITION

Should Serve to Stimulate American Aviation

PARTICULARLY in aviation is there discussion of what British competition after the war will mean to the United States. It seems probable that British competition will be the best possible stimulus to American aviation. Competition from our British friends should be welcomed. In the matter of cargo and transport design they are at present handicapped because, while United States airlines are in full swing and carrying goods to the far corners of the earth, British airlines—for obvious reasons—have mostly suspended operations.

Nevertheless, the British are not asleep and quite recently the Air Secretary, Sir Archibald Sinclair, has announced that seven types of British air transports are now being considered or designed. These include transatlantic land planes, one of them of over 100,000 pounds with a pressurized cabin.

Here, perhaps, is a lesson for American aviation. Fying boats are costlier to operate than land planes of the same size, and their price of daily utilization is less. Perhaps airlines of the United States should also use land planes across the Atlantic.

This revival of British interest in commercial aircraft should be welcomed. Friendly rivalry between America and Britain should always remain friendly rivalry and remarks to the contrary may be considered as propaganda.

Electronic Controls

Second-by-Second Measurements of Gas Content of Air; Constant Supervision of Rate of Flow of Liquid in a Pipeline; and Control of a Specialized Distillation System are Only Three Examples of the Possibilities of Electronic Control in Everyday Industrial Operations

By VIN ZELUFF
Assistant Editor, *Electronics*

MANY industries are concerned with the problem of controlling liquids or gases that are products or by-products of the manufacturing processes. Often these materials are inaccessible to the usual methods of measurement or control because they are confined in pipes or containers, are poisonous to personnel, or are vulnerable to impurities or adulteration. For solving such difficulties, electronic devices are particularly well suited since they can be adapted to fit the special conditions required.

Elaborate air-conditioning systems, special suction hoods, and so on, are employed in many manufacturing plants to draw off vapors and gases that force workers to wear gas masks during certain operations. In spite of these precautions, it is usually necessary to make periodic checks of the air in various parts of the plant to determine whether the concentrations of the volatile substance is being held within the safety level.

Most gas analyzers require 15 minutes or more to take an air sample, and show only the average concentration of the gas during that period of time. With this technique, momentary high peaks escape observation. An electronic instrument recently developed at E. I. du Pont de Nemours can run continuous samples, however, and give direct and instantaneous readings. This permits accurate second-by-second observation of the vapor level in each step of a manufacturing process.

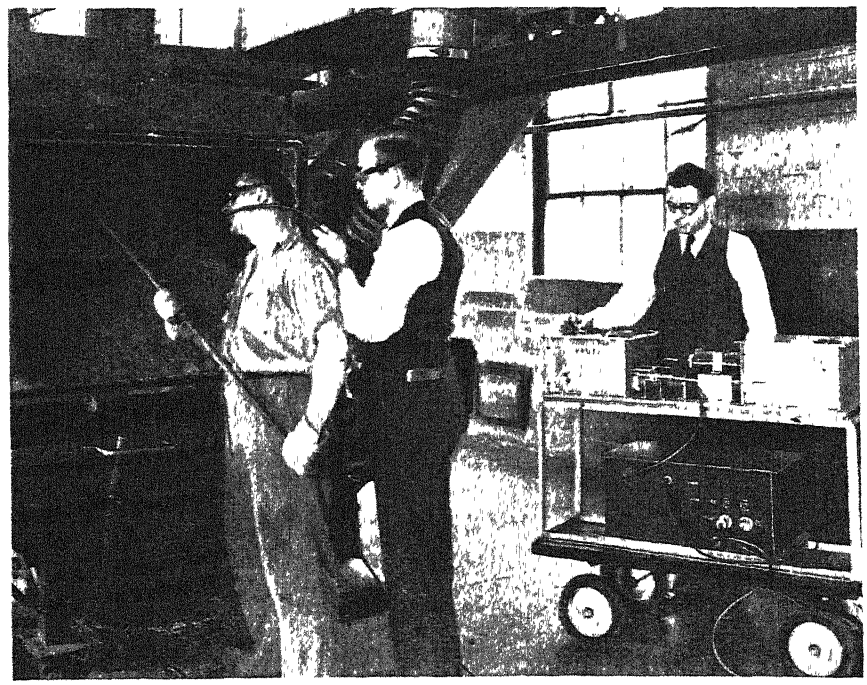
The new electronic gas analyzer, called an ultra-violet photometer, is based on the phenomenon of light absorption by gases. Most gases absorb light of some particular wavelength, in effect casting a shadow where that particular wavelength line would otherwise have fallen. In a spectrum, that shadow is known as an absorption line. Carbon disulfide, for example, strongly absorbs light having a wavelength of 3132 Angstrom units, in the ultra-violet range.

The instrument is so constructed that the air to be analyzed is pumped through several small chambers which filter out dust, oil, and moisture, and thence into a pair of parallel tubes, about 31 inches long. The contaminated air runs into the first tube and then through a canister of activated charcoal which removes carbon disulfide, passing purified air into the second tube This permits a continuous comparison of the purified with the contaminated air and very minute differences may be detected.

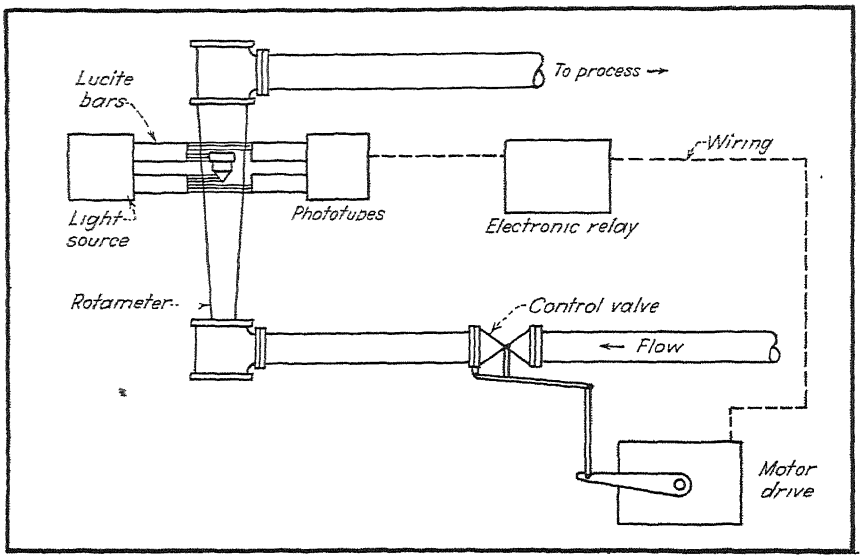
Rays of ultra-violet light from a mercury lamp pass through the two tubes and fall upon a sodium phototube mounted at the opposite end of each tube A vacuum-tube amplifier follows the phototubes and actuates a microammeter for readings.

Filters in the optical system have been so selected that about 60 percent of the photometric response of the phototube is due to light of 3132 Angstrom units in wavelength, the light which carbon disulfide absorbs No other atmospheric element has been found in plants where this instrument is used that absorbs either this band of light or the 3650 Angstrom unit band which accounts for most of the remainder of the phototube's response. One part of carbon disulfide in a million parts of air will produce an absorption of 0.02 percent.

TESTS IN SECONDS—In one test, 61 readings were made during the nine minutes required to open, dump, and clean out a large vessel in which material was treated with carbon disulfide. During most of the operation, the concentration of gas remained below 20



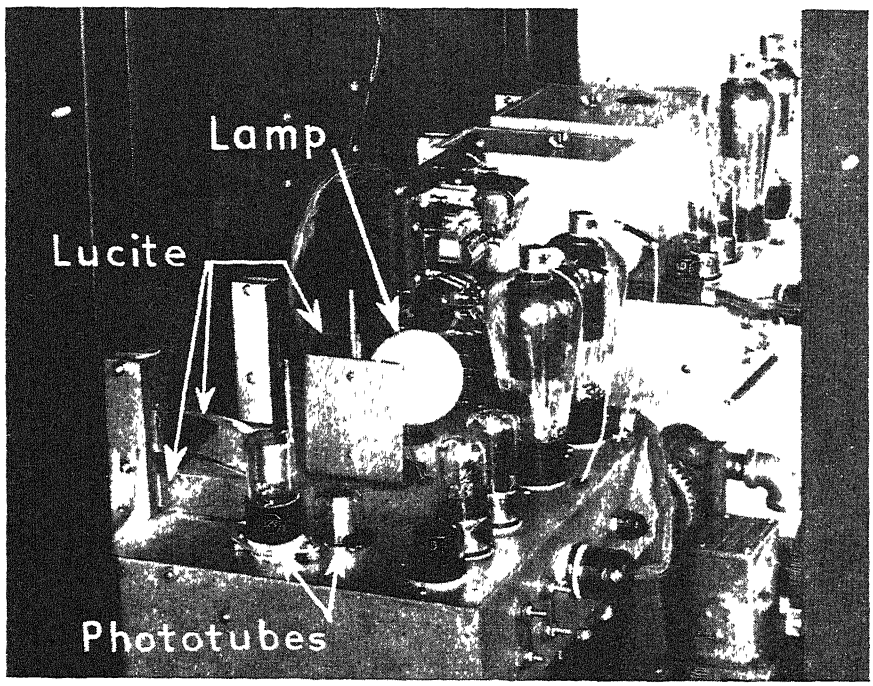
Engineers in the Du Pont plant are shown here using the new electronic gas analyzer to check the efficiency of a hood system used to draw off fumes during a production process. The intake of the analyzer is held at operator's nose level

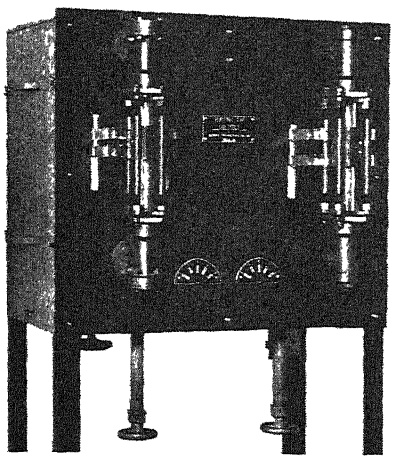


Above: Block diagram of phototube control system for fluid flow. The valve is opened or closed by the electric motor which in turn is controlled by the relay and phototubes

Right: Close-up of the interior of the electronic flow control unit. Plastic bars transmit light from the lamp through the panel and through the rotameter glass, then back through the panel to the phototubes

Below: The complete electronic flow control unit. Note the plastic light-transmission bars projecting through the slots in the face of the panel





parts per million. Here older methods of analysis, which could give only the average for this entire time interval, would have shown no danger points. However, the ultra-violet photometer revealed that the concentration rose to 60 parts per million at one moment and to 40 at another. The ventilating equipment was therefore modified in order to eliminate these peaks.

For many years there has been a demand for automatic control to be applied to the rotameters used to indicate the rate of flow of liquid or gas in a pipe line, so that changes would cause a motor to open or close a valve and thereby correct the flow rate. Brooke Engineering Company recently developed a control for this type of meter for a large refinery that had a process in which they wished to maintain the flow rate of a fluid to within ¼ percent of a predetermined value. It was decided to use an electronic relay, receiving its signals from phototubes positioned near the rotameter. This instrument consists of a vertical, transparent, tapered glass tube and a float-type metering element inserted inside the tube. The small end of the tube is at the bottom, and the float (also called the rotor) is free to move up or down along the axis of the tube. The position assumed by the float directly indicates flow rate. The gas or liquid being metered flows from the bottom to the top of the tube. The forces on the float are in balance; weight of the float minus buoyancy equals the area of the top of the float times differential pressure. If the flow rate increases, the differential across the float will increase, and the float will rise to a new position to maintain a fixed differential pressure across it. Rate of flow is thus accurately indicated by the position of the float.

For the rotameter application, it was decided to use two light beams, one shining across the top of the float, and the other across the bottom of the float. Each light beam was applied to a phototube, and the outputs of the phototube amplifiers were electrically balanced against each other to cancel out the effects of voltage changes and color deviation of the liquid

If the float in the rotameter moved due to a change in flow, one phototube received more light and the other less light. This unbalance caused a thyratron tube to operate a motor which changed a control valve in the correct direction to restore the float to the set value.

The rotameter is mounted on a stand in front of a panel, and the electronic relay, with its light source common to both beams, and its phototubes, amplifiers, thyratrons, and allied equipment, is mounted behind the panel. Lucite or Plexiglas bars are used to transmit light to the rotameter and to the phototubes. The electronic relay is mounted on an elevator assembly which permits the operator to raise or lower the entire assembly to change the rotameter control setting which determines the flow rate.

Another feature that may be included in the electrical circuit provides for automatic shut-down if any of the fluids in the process cease flowing or go beyond predetermined values, or if tubes or light source fail

A lock-in circuit is employed to return the float within the range of the light beam if the characteristics of flow are such that an occasional surge in the fluid will raise or lower the float out of the light beam. Essentially, it consists of electromagnetic relays which are actuated by the phototube amplifiers just before the float leaves the light beam. The lock-in feature discerns which way the float moved and operates the motor at full speed to return the float to the light beams where the thyratron can come into operation

The light source is a 120-volt bulb directed through two pieces of Lucite or Plexiglas to form two light beams shining across the rotameter. They are spaced so that when the float is in balance, one half of each light beam is blocked out and the other half of the beam passes through the fluid and metering tube to other bars of Lucite, and thence to the phototubes.

Circuit values are so chosen that if the float moves at a great distance, the motor will run at full speed without interruptions As the float approaches neutral, the motor begins to step (stop and start) at a rate proportional to the distance from neutral.

Thus the motor always has full torque, regardless of how close the float is to balance. This is important for sensitive controls—otherwise, should the valve stick, the torque delivered by the motor near the neutral point would be insufficient to restore the float to the original balance point

Successful field operation of 64 of these units for several months has shown that an extremely accurate control can be applied to devices where it is necessary to maintain a movable body in a fixed position.

Electronic control of liquids has another new industrial application, wherein a system of stills for producing pure water is operated automatically, with heat being turned on and more water added as demanded by laboratory requirements.

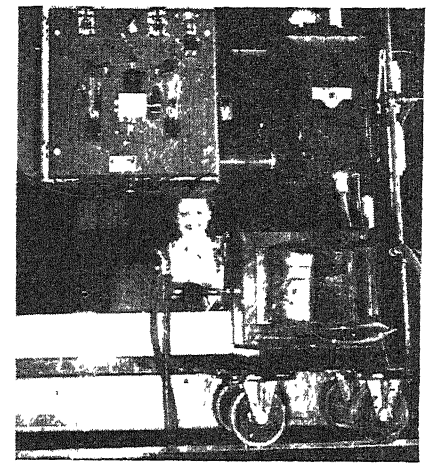
ONE PART IN A MILLION—With some of the materials used in the field of electronics, such as phosphors, electron-emitting coatings, and photosensitive surfaces, the presence of one part in a million of a given impurity may alter some specific property by several orders of magnitude Since water is used in large quantities for almost all chemical manipulations, it is essential that a sufficient supply of very pure water be available for manufacturing processes involving these materials. Three distillations will serve to produce water suitable for most uses.

In RCA Laboratories, an industrial requirement of approximately 10 gallons per day of double-distilled water and five gallons per day of triple-distilled water made it desirable that some sort of continuous system be employed which would operate with very little attention. Here the primary distillation takes place in a conventional commercial still which feeds its product into a large glass-lined storage tank From there the water is fed by gravity to the second stage of distillation. The second and third distillations are carried out in all-Pyrex stills, completely protected against airborne dust

The problem involved automatic control of electric heater current and control of the water level in the glass boiling flasks. Two platinum probe wires were sealed into the system at the desired minimum water level, and connected to an electronic relay sensitive enough to respond to the extremely small current that flowed between the probes through the water. When the water level drops below the probes, the electronic relay then operates an ordinary electromagnetic switch controlling the electric heater current for the boiling flasks, and at the same time operates an electromagnetic valve located in the waterfeed pipe

An electromagnetic valve of the vertical-lift type, utilizing a spherical ground-glass joint as seat and plunger, proved satisfactory. A soft-iron laminated core is completely sealed in a glass tube that extends into the center of a surrounding solenoid. Energization of the solenoid lifts the plunger, permitting water to flow without contamination by metal at the valve When no current is flowing through the solenoid the weight of the core is sufficient to close the valve

The electronic relay has been in operation without a single failure for nearly one year No adjustments beyond those made during the original installation have been required



Electronic tubes control flaw-finding current. Transformer at right is moved to different positions as required by the process operator

FLUOROSCOPY

Speeds X-Ray Examination of Many Products

IN THE post-war world, the Government will not require x-ray inspection of airplane castings, tank welds, armor plate, and so on, although there may be safety regulations calling for x-ray inspection of parts of airplanes used as public carriers.

Many industrial x-ray users who started using the equipment because of government requirements will continue to use x-rays to improve quality, reduce costs, and save labor. One contribution to industrial x-ray expansion is the improvement of presently available types of x-ray machines and the creation of new machines and accessory devices. Progress thus far has been much greater along the lines of straight radiography than fluoroscopy, but nevertheless the fluoroscope has been used to spot the presence of foreign bodies in packaged products. One large manufacturer of chewing tobacco experienced labor troubles and when the strikers left their jobs they tossed nails, hairpins, and other articles into the pile of unpackaged tobacco. That tobacco company now has a fluoroscope and a girl observes and checks every package.

Fluoroscopic inspection allows instant separation of the good from the bad —no film, no dark room, no delay, yet complete inspection beneath the surface of a product

FLAW FINDING

Made Less Expensive by Electronic Current Source

BOLTS and other parts made of magnetic material are being inspected by an electromagnetic method at the Buffalo plant of Curtiss-Wright Corporation, using electronic equipment as the power source. This method shows up flaws and cracks and can handle part sizes ranging from small bolts to reasonably large castings.

When electric current is passed through a magnetic substance, a north and south pole are produced at each crack in the material When finely divided iron oxide in solution is poured over the material, the oxide particles adhere at the cracks and make them readily visible. The importance of such electromagnetic inspection operations in the production of aircraft has long been considered a vital necessity as a safety measure.

This method of inspection required a large amount of current from storage batteries Maintenance costs on battery equipment were approximately $3000 yearly. To replace the batteries, the electronic equipment shown in the photograph provides a source of power which is constant, day in and day out, at a fixed amperage. By the use of thyratron and ignitron tubes a current impulse of 40,000 amperes is available, which provides deeper penetration and greater concentration of the iron-oxide particles The estimated yearly maintenance costs of the electronic equipment is $50, principally for replacement of vacuum tubes.

LEAKERS SPOTTED

By X-Rays in Cathode Tube Plant

BEFORE precious man-hours and material have been expended on final assembly, routine x-ray examination with a Picker 150,000-volt industrial unit is used in one cathode-ray tube plant to detect porosity, faulty welds, and other internal weaknesses that would affect performance of the tubes. When the trouble is found before final assembly and sealing of these costly tubes, it can often be corrected by simple application of heat, thereby salvaging many essential tubes. The "leakers" that would allow air to get into the tube after evacuation are generally found to have flaws at the terminal caps at which connecting wires pass directly through the glass walls.

Why Engines Knock

Fuel Knocking Can Threaten Destruction to Engines. Technologists Are Familiar With Some of the Answers to the Problems Involved, But Many More Data Are Required. New Research with a Full-Scale Engine Test Stand Is Pointing the Way Toward Better Fuels for All Gasoline Engines

By DR W. J SWEENEY
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THE CHIEF limiting factor in aviation fuel performance today is the familiar tendency of most petroleum hydrocarbons to knock under increased power conditions, and thus to threaten destruction of the very engines they operate. For this reason there is need for considerably more full-scale engine test data to guide our further improvement of fuel quality. The improvement may come through better knowledge of the anti-knock qualities of various individual hydrocarbons. This in itself is a complicated problem because there are possibly millions of different hydrocarbons present in petroleum Alternately, the improvement may come through better engine design to meet knock conditions. In any case, the measure of this improvement must be made by closer reference to actual test data, obtained in representative aircraft engines.

To perform its function, the aircraft engine must produce the maximum amount of power, consume the lowest possible amount of fuel, and weigh as little as is consistent with the strength it must have to withstand the terrific stresses imposed upon it. Unfortunately, these things are to a considerable degree contradictory: for example, the power output of the engine when operating at its best economy (on the lowest weight, or quantity, of fuel) may be limited by knocking. To obtain maximum power, it is necessary to take steps to avoid this knocking. This is done by enriching the mixture—feeding to the engine a larger proportion of fuel to air than it theoretically needs to produce that power.

Table A
ACTUAL VS. THEORETICAL ENGINE (7 to 1 COMPRESSION RATIO)

	ACTUAL		THEORETICAL	
Total heat in fuel, Btu/lb.		19,000		19,000
Heat lost to exhaust, Btu	6,500		8,500	
Heat lost in cylinder cooling, Btu	6,000		0	
Total heat lost, Btu		12,500		8,500
Usable heat: available to prod. work		6,500		10,500
Thermal Efficiency ($\frac{\text{Usable heat}}{\text{Total heat}}$)	34%		55%	
Theoretical pounds of fuel per brake horsepower hour (no heat losses)	(0.134)		(0.134)	
Actual pounds of fuel per brake horsepower hour at stated efficiency	0.394		0.244	

Before looking into the reasons why this is so, let us first see what knocking is In Figure 1, top, is shown a tube of fuel-air mixture, ignited at one end by a spark plug The following sequence of events occurs

(1) Ignition of the mixture by the spark plug.

(2) Relatively slow burning of the mixture, progressing away from the spark plug

(3) Rapid increase in pressure and temperature of the unburned portion of the mixture ahead of the flame front until a condition is reached which makes that unburned mixture explode violently or detonate (bottom of drawing).

(4) Pressure waves set up within the cylinder, resulting in knock; rapid scrubbing of walls by vibrating gas, rise in temperature of walls, loss in engine power, and eventual destruction of parts.

If fuels did not vary in anti-knock quality or tendency to knock, they could all be evaluated reasonably by one characteristic—the number of heat units (Btu) per pound. However, knock is a very bad actor. It limits economy (range of operation) and it limits power (performance).

Modern aircraft fuels are miracles of high anti-knock quality. They have permitted engines to be built capable of developing power outputs undreamed of only a short time ago This great team of engine and fuel powers our fighting aircraft today Nevertheless, these engines must still employ rich, relatively uneconomical mixtures in order to develop maximum power for take-off, climb, and high speed, yet during normal cruising operation to function on lean, economical mixtures

EMPHASIS ON AIR—An aircraft engine is a device for converting heat energy into mechanical energy or useful work. Its working fluid—that is, the expanding gases which perform work—is the nitrogen from air plus the products of combustion. These combustion products are the gases carbon dioxide, carbon monoxide, water vapor, and hydrogen, in varying proportions depending on the conditions of burning in the cylinders. It is a fact not generally appreciated that the power output of a gasoline engine is more nearly proportional to the amount of air (or oxygen in the air) burned than to the amount of gasoline consumed This should be kept in mind. It is the reason why aircraft engines are supercharged or "boosted" to increase manifold pressure for take-off and for operation at high altitudes.

If the thermal efficiency of an actual engine is compared with that of a theoretical engine it is found that the actual engine is naturally much less efficient than the theoretical engine. since it has mechanically operated valves which require time to open and close, thus permitting dilution of the fuel charge with exhaust gases, and because the mixture will not burn instantaneously after ignition. Moreover, it is impossible in an actual engine to prevent heat loss from the gas to the walls, and the temperature that the

Table B

100 percent of Theoretical Fuel (Cruise or maximum economy lean mixture, fuel/air ratio = 0.067)

$1\ CH_2 + 1.5\ O_2 \rightarrow CO_2 + H_2O$

Heat evolved = 19,000 Btu/lb. fuel

or 1,270 Btu/lb. air

150 percent of Theoretical Fuel (Take-off or full-power rich mixture, fuel/air ratio = 0.10)

$1.5\ CH_2 + 1.5\ O_2 \rightarrow 0.53\ CO_2 + 0.97\ H_2O + 0.97\ CO + 0.53\ H_2$

Heat evolved = 10,900 Btu/lb. fuel

or 1,090 Btu/lb. air

metal parts of the engine can stand are limited Therefore heat must be removed in order to keep temperatures of cylinders and pistons within safe limits. Heat likewise is removed by the lubricating oil. All this means fins for cooling cylinders and lubricating oil, which place an added drag on the airplane; special metals to withstand high temperatures; engine lubricants to function under these severe conditions, and many other problems which the designer, the metallurgist, and the oil refiner must solve.

Roughly, the total heat in a pound of fuel is divided as shown in Table A. This, however, applies only to operation with the theoretically correct ratio of fuel to air—typified in practice by cruising conditions at low power

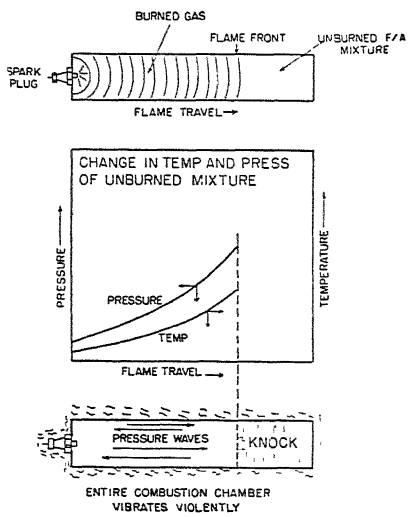


Figure 1: How knocking occurs

output. For high power output, as at take-off, an engine designed to give maximum fuel economy at cruising conditions must run with a rich mixture—a higher ratio fuel to air; for otherwise it would knock, overheat, and quickly be destroyed.

The simple chemical equations in Table B show why rich mixtures produce less heat, hence less knock. They show the relative volumes of gases produced and the relative quantities of heat evolved when a given volume of oxygen in the air combines with or burns a hydrocarbon in lean mixture and in rich mixture, respectively.

These considerations show that, with rich mixtures, the heat evolved per pound of fuel or per pound of air is reduced. This produces less temperature rise in the cylinders, and less tendency to knock. This permits an increase in air supplied to the engine by means of added boost or supercharging, and added fuel, and this in turn permits greater power outputs before knocking again occurs

Although all fuels will knock less in rich mixtures than at the theoretically correct fuel/air ratio, some are better than others in this respect.

Table C shows what this means in terms of power output and fuel consumption in an aircraft engine of 2000 rated brake horsepower: Here it is seen that fuel consumptions at cruise, rated continuous, and take-off are 0.40, 0.525, and 0.67 pounds per B.H P. hour and corresponding thermal efficiencies 34, 26, and 20 percent. For the increase of 600 horsepower to bring the engine to rated continuous power, fuel consumption is at the rate of 0.82 pounds per B.H.P. hour, and thermal efficiency is reduced to 16 percent Fuel consumption for the increase from rated 2000 to 2400 take-off horsepower jumps to 1.38 pounds per B.H.P. hour, and thermal efficiency for the same range drops to 10 percent. Full power, rich-mixture operation is expensive

POSSIBLE IMPROVEMENTS—This indicates where improvements in fuel quality can, in the future, help reduce airplane operating costs or improve performance. There are a number of ways that these benefits might be effected:

(1) Same cruise quality but better rich mixture quality, so that same power as at present could be obtained with less enrichment. Result: better economy.

(2) Same cruise quality but better rich mixture quality, so that greater power could be obtained with same enrichment as at present. Result: better performance. (Such performance helped win the Battle of Britain.)

(3) Better cruise quality and same rich mixture quality. Result: greater range of operation. (This fuel may help with the Battle of the Pacific.)

(4) Better cruise quality and better rich mixture quality. Result: greater range and better performance. (Such a fuel would be an improvement over (3) and would be even more valuable in the Japanese conflict)

Figure 2 shows how knock affects economy or range of operation of an aircraft. The higher the compression ratio—and accordingly the higher the temperature—the better will be the resulting economy for a given power output Neglecting mechanical considerations, the tendency of a fuel to knock limits the compression ratio with which it can be used, and hence

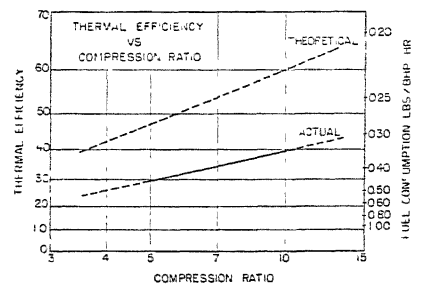


Figure 2: Knocking and economy

the economy or range that can be attained.

Figure 3 presents three schematic indicator cards showing the increased cylinder pressures, and hence greater powers, which are obtainable without knocking when richer mixtures are used. (For simplicity the power increase that is gained in practice by increasing speed has been neglected.) Three work areas are shown. These roughly represent the three conditions listed in Table C. In each case the limit of permissible power is due to knock; but different fuels will show different rates of change in permissible power with rate of change in the ratio between fuel and air.

The adjustments necessary to handle these changes in fuel/air ratio are complicated and to relieve the pilot the carburetor is designed to take care of them automatically. There are two

Table C

	CRUISE	RATED CONTINUOUS	TAKE-OFF
Horsepower delivered	1,400	2,000	2,400
Lbs. fuel consumed per hr.	560	1,050	1,600
Gallons fuel consumed per hr. (assuming 6 lbs. per gallon)	94	175	266
Fuel/Air Ratio	0.07	0.085	0.10
Total heat in fuel, Btu (assuming 19,000 Btu per lb.)	10,600,000	20,000,000	30,400,000
Heat to produce power, Btu	3,600,000	5,100,000	6,100,000
Heat lost, Btu (difference)	7,000,000	14,900,000	24,300,000
Fuel consumption rate, overall lb. per B.H.P. hr.	0.40	0.525	0.67
Thermal efficiency, overall	34 percent	26 percent	20 percent
Pounds of fuels per B.H.P. hr. (incremental)	———	.82	1.38
Thermal efficiency (incremental)	———	16 percent	10 percent

settings, automatic lean and automatic rich,' determined by experience, and the pilot has the choice of either to obtain economy or power as required With these settings the carburetor automatically supplies enough fuel, based on the quantity of air passing through its throat, to prevent knock under any normal conditions when running on the proper fuel In certain large long-range aircraft, however, the flight engineer may over-ride the controls manually and approach incipient knock as closely as he dares, in order to obtain maximum economy and hence greatest range.

A comparison of fuel quality on a lean-mixture performance and a rich-mixture performance basis is admittedly an over-simplification of the knock problem because other variables enter into the picture—such as compression ratio, spark advance, cylinder cooling, mixture temperature, speed, hot spots, and so on. Nevertheless, the wide differences in fuel quality under different operating conditions can readily be shown by such a comparison

There are millions of possible hydrocarbons and the number present in petroleum is probably in the hundreds of thousands. Within the gasoline boiling range alone the number possible is around 5000 Of these, however, only a few dozen are known to be of superior anti-knock quality. Table D gives a comparison of relative knock quality of some of these hydrocarbons with pre-war commercial fuels (the completely arbitrary scale used is not to be confused with octane number).

These ratings are not necessarily true quality measurements, but do serve to indicate the wide variations in fuel performance that can be obtained by varying engine operating conditions. The great differences in the lean mixture and rich mixture ratings of some of these fuels show that it is extremely important that the tests used to evaluate the fuels determine their quality in actual flight.

TWO INTERESTING THINGS—The data in Table D show two things which are of particular interest:

(1) Existence of hydrocarbons that, with both lean and rich mixtures, exceed old-style 100 octane gasoline in anti-knock quality.

(2) The extremely great rate of change in anti-knock quality, in many cases, between lean mixture and rich mixture Should the latter degree of severity more nearly represent average flight performance than the former, the actual relative performance would in some cases be the opposite from that derived from data based on lean mixture ratings

Assuming that between the two extremes lie the actual knocking conditions experienced in flight, it is obviously important to know just where incipient knock is reached under different flight conditions and in different engines

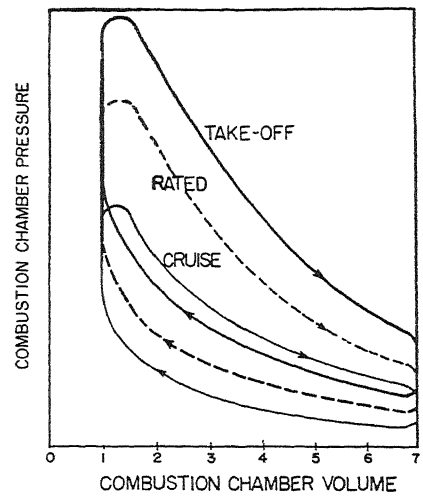


Figure 3: Richness and power

To redesign engines and aircraft to take full advantage of fuel improvements is no easy task. One phase of the job is to prove by adequate full-scale engine tests that the fuel has the added quality, to what extent and under what conditions of operation. Another is to determine what changes in superchargers, carburetors, ignition systems, coolers, and so on, must be made to get the most from the new fuel-new engine combination. The fuel and the engine are, in a sense, like the hen and egg—which comes first?

The engine manufacturer cannot build his engine in production quantities until the fuel it needs is commercially available The refiner cannot build the equipment for making the fuel without knowing what its composition must be to meet the needs of the engine The fuel designer in his laboratories must arrive at this composition on the basis of practical tests To meet this need—the very foundation of fuel and engine improvement—Standard Oil Development Company has built a half-million-dollar full-scale multicylinder engine test stand

It is quite impossible to do all fuel test work on engines in flight, for several good reasons For example, flight conditions of air temperature to carburetor and air temperature to cooling fins cannot be reproduced from day to day Also, it is desirable in rating fuels to approach knocking conditions—thereby occasionally developing true knock, a most dangerous condition in flight While a good bit of flight data is absolutely necessary, it is generally desirable to obtain the background data on full-scale laboratory engines and then to check special points by flight tests It is for such evaluations of presently available commercial blending agents and of promising experimental products that the new full-scale test stand has been built

By present standards, petroleum as found in nature provides very poor aviation fuels. Broken down and synthesized, however, it gives exceedingly good fuels As it will be produced in the future, petroleum gives promise of even greater improvements in anti-knock quality Even now—in the midst of war—much can be done to improve fuel quality by selection of available product and modification of existing plants. Such improvements are the immediate aim of all of us operating the test stand; so that, no matter how long the war, the Armed Forces will have available the best possible fuels compatible with the huge amounts required

Table D

COMPARISON IN ANTI-KNOCK QUALITY OF PURE HYDROCARBONS AND PRE-WAR COMMERCIAL FUELS

(All with same lead content except where indicated)

HYDROCARBON	LEAN MIXTURE	RICH MIXTURE	DIFFERENCE
A	77	100	+23
B	70	93	+23
C	57	99	+42
D	54	76	+22
E	47	49	+ 2
"100 Octane" (1938)	42	52	+10
F	42	46	+ 4
G	42	40	—2
H	31	34	+ 3
"91 Octane" (1938)	28	37	+ 9
I	21	19	—2
J	21	15	—6
K	14	14	0
"73 Octane" (1938) (no lead)	2	9	+ 7

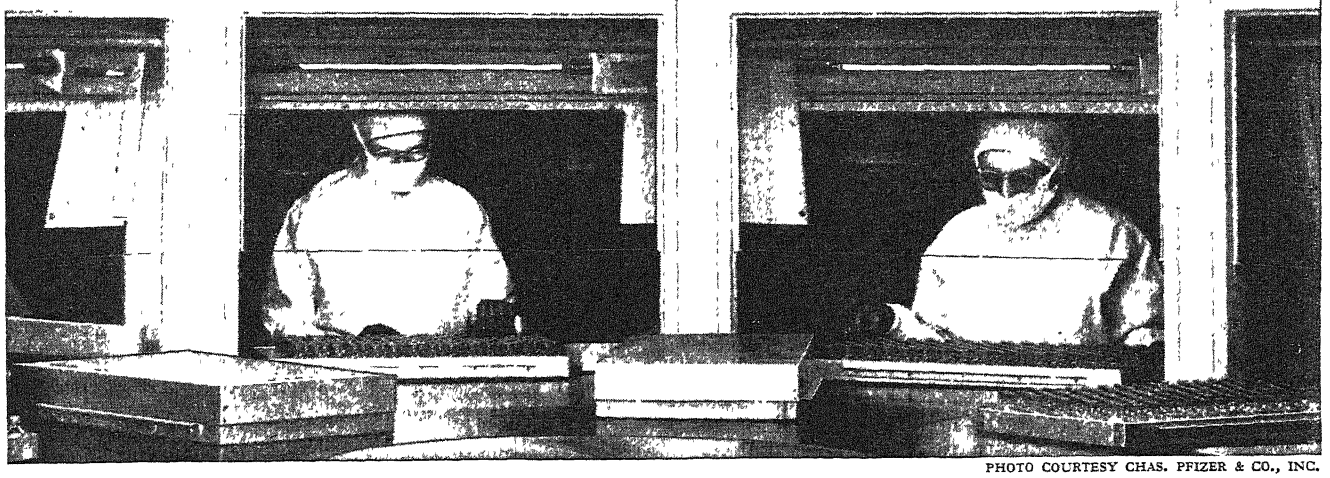
WOOD IN PLANES

Used Because of Its Adaptability

More than 16 types of wood go into the building of the giant Douglas C-54 The woods used range from featherweight rattan to heavy mahogany Chinese rattan, because of its lightness and flexibility, is used in beading upholstery. Paratroop benches are made from New England ash. Other woods go into assembly jigs, hand-form blocks, trim jigs, check jigs, and pattern work Balsa is used as a filler in partitions and floor boards.

According to A. O. Schroeder, veteran Douglas woodcraft expert, about 30 percent more wood is used today in aircraft than just a year ago, largely because of metal shortage. "A woodshop will always be essential for the fabrication of planes," comments Schroeder.

THESE SLENDER TUBES...



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For Sterilamps are standard equipment in leading biological laboratories—protecting the precious *Penicillium notatum* mold from air-borne contamination that would destroy the curative powers of penicillin.

Thus the Sterilamp—perfected in the Westinghouse Research Laboratories—has scored *another* notable victory over the invisible enemies of mankind.

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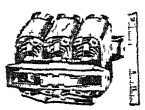
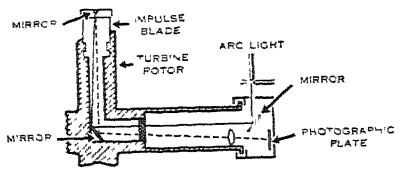
KEEPING UP WITH *Electricity*

USING A LITTLE LIQUID AIR and some warm water, Westinghouse engineers now "manufacture" pocket-sized clouds and snowstorms that would fit into your hat, to help the Westinghouse Research Laboratories speed development of more powerful electrical systems for American warplanes. In a glass flask not much bigger than a milk bottle, artificial clouds and snowflakes are used to test the effectiveness of electrical insulation under conditions encountered by real airplanes at altitudes up to 12 miles.

MIGHTY MIDGET . To save precious pounds for extra fuel and ammunition, Westinghouse engineers have developed a 35 kilowatt transformer, for alternating current aircraft systems, which weighs *only 25 pounds*—less than 1/25th the weight of conventional transformers of



similar rating. The secret of this weight-reduction is 400 cycle frequency, forced air cooling and the use of new, thin-gauge Hipersil steel in transformer core.



DONE WITH MIRRORS . . . To find out just what happens inside a steam turbine, Westinghouse research engineers worked out an ingenious system of mirrors—by which they actually photograph minute vibrations in turbine blades whirling at the terrific speed of 350 miles per hour. Result: important improvements in turbine blade design and greater insurance against turbine failure.

Glass In Textiles

Problems of Filament Formation and Lubrication Have Been Solved, and Extensive Experimental Work is Going Forward on Combinations of Glass and Other Fibers. Coated Glass Fabrics Open Entirely New Fields of Application, as Do Also Glass-Plastics Combinations in Laminate Form

By WILLIAM H PAGE

NON-FLAMMABILITY and resistance to the effects of high temperatures are rare properties in textiles. It was partly due to the need for a textile possessing these properties that glass technicians, more than half a century ago, began to devote serious attention to the attempt to produce glass fibers sufficiently pliable to be woven into fabrics.

As early as 1893, Edward D. Libbey, of the Libbey Glass Company, succeeded in drawing relatively coarse fibers from the heated ends of glass rods. Using the glass fibers as the warp and silk threads as the fill, lampshades were made which were shown at the Columbian Exposition in Chicago. There a celebrated actress saw them and arranged to have a dress made of the same material Great crowds flocked to see her in her glass dress. Many went away disappointed, for they had come believing the dress would be transparent.

This was not the only disappointment. Because of the presence of the silk, the fabric was not fire-proof, and it was too stiff to be creased or folded. A fabric could not be woven with the glass fibers alone The result of Mr. Libbey's experiment was spectacular, and it attracted a great deal of attention, but it proved to be of no practical value.

The degree of pliability of glass is governed by the relation between its diameter and its length. This is also true of steel and many other materials. Steel is rigid in a thick, short piece, but heat it and draw it out into a fine wire and it becomes extremely flexible. The same holds for glass, but if glass is to be truly pliable, diameter must be much smaller, in relation to length, than is required in the case of steel.

Another factor that has to be taken into consideration in attempting to weave a glass fabric is that all fibers tend to abrade each other when they are twisted into yarns. Fibers such as wool, cotton, silk, or linen, contain a natural lubricant which minimizes abrasion. But glass contains no such lubricant, and glass tends to cut glass, just as a diamond will cut a diamond

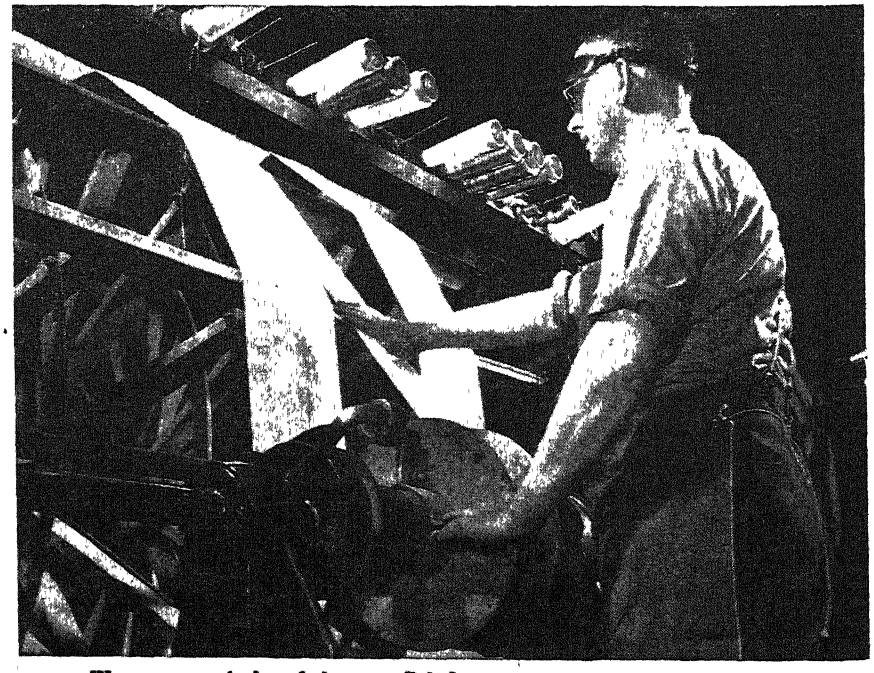
A third factor is expansion of surface area. It is generally assumed that, aside from breakage, glass is practically indestructible. But some glasses are more resistant to surface attacks than others, and the greater the surface area, the greater is the opportunity for these attacks to occur. When a mass of glass is drawn into fine fibers its surface area is increased immensely. The glass fibers must be provided with resistance to weathering, chemical action, and other influences to which they may be exposed.

Years of research and the expenditures of many millions of dollars were required to develop methods for producing glass fibers which would meet these and other requirements When, in 1936, what is now Owens-Corning Fiberglas Corporation finally succeeded in producing serviceable all-glass fabrics, the methods employed differed radically from the crude process used by Mr Libbey in his work in 1893

These 1936 methods, with improvements which have made it possible to produce steadily finer, stronger, and more pliable glass fibers, are basically the same as those now employed to produce all Fiberglas textiles. The raw materials of the glass batch are mixed in accordance with formulas which give the fibers high resistance to surface attacks. Special lubricants, sprayed on the fibers as they are formed, minimize abrasion.

HOW FIBERS ARE FORMED—The fibers are formed either by high-speed drawing, for continuous filaments, or the yanking action of high-pressure steam, for staple fibers. Continuous filament textile fibers are produced by gathering together 100 or more filaments of glass as they emerge from as many tiny holes in the base of a melting chamber, and winding the strand on a winder revolving at high speed. Because the winder revolves much more rapidly than the filaments flow from the melting chamber, the filaments are attenuated to a fraction of the diameter of the holes through which they emerge.

Staple textile fibers are formed by the action of jets of high-pressure steam as they strike thin streams of glass emerging from holes in the melting chamber. The steam literally yanks



Warp yarns of glass being paralleled preparatory to weaving into fabric

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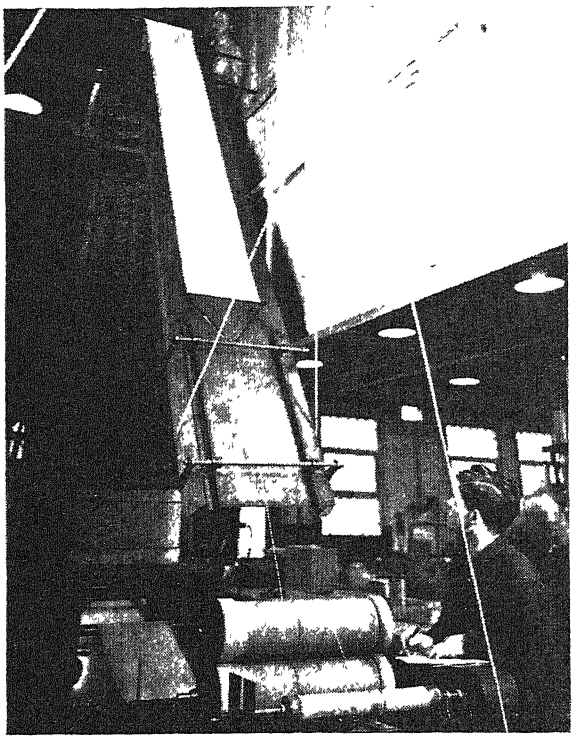


When Fiberglas is to be used as a reinforcement for plastics, the cloth must first be heat-treated to provide the required adhesion between the glass and plastics. Here a strip of the glass fabric is shown emerging from the heat-treatment hot-air tower

the glass into fibers varying in length from 8 to 15 inches. The fibers are driven down onto a revolving drum on which they form a veil resembling a cobweb. The gossamer web of fibers is wound on a tube in the form of a soft strand.

Continuous filament and staple fibers are twisted, plied, and woven on standard textile machinery adapted to handling glass textiles. The fineness and strength of the glass textile fibers are almost incredible. Fibers with a diameter of 23 one-hundred-thousandths of an inch have a tensile strength of more than 250,000 pounds per square inch. Experimental fibers have been produced with a diameter of two one-hundred-thousandths of an inch and with a tensile strength exceeding 2,000,000 pounds per square inch.

WAR-TIME USES—When impregnated with suitable varnishes, Fiberglas fabrics offer high resistance to the flow of electric current. The varnish-impregnated glass fabrics occupy little space, and are resistant to high temperatures. For these reasons, tapes, braids, and cloths made of these fabrics were already in wide use as electrical insulation before the war. Because the size and weight of an electrical unit required to do a given job is largely determined by the heat the insulation will bear, use of glass insulation has enabled design engineers to reduce the size and weight of motors, transformers, and other electromagnetic machines.

Other pre-war applications of Fiberglas fabrics were as widely divergent as their use as decorative fabrics and as filter cloths for the processing of chemicals. The fact that glass fabrics will not burn is their outstanding advantage when used for draperies, tablecloths, or bedspreads. Resistance offered by the fabrics to heat and acids (except hydrofluoric acid) makes it possible to use them for filtering hot, concentrated acid solutions

Since the attack upon Pearl Harbor, practically the entire output of Fiberglas fabrics has been devoted to war uses The fabrics are used as electrical insulation in equipment for ships, planes, and other machines of war, or production for war One of the smallest but most vital motors in a plane is the pitch-change motor which changes the pitch of propellers that have gone dead, so that the blades are turned edgewise to the wind These motors are insulated with Fiberglas.

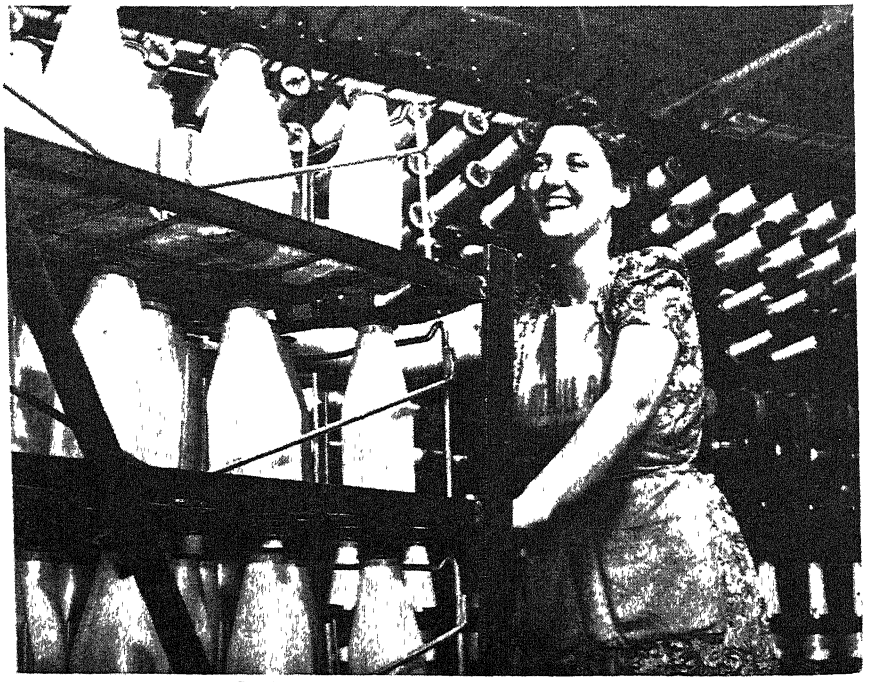
Glass fabrics are employed in numerous other war applications where non-flammability and resistance to high temperatures are required A spectacular war application has been their use as glare shields for the magnesium parachute flares of about 1,000,000 candle-power which are employed by the Army Air Forces to illuminate the objective of a bombing attack. Fiberglas tapes and cloths are used to wrap insulated piping on Navy ships and exhaust pipes on planes. Curtains of glass fabric have replaced certain doors on both Navy and merchant ships.

War requirements have been largely responsible for a number of developments that forecast new or broader peace-time uses of glass textiles The needs of the armed forces have led to the development of Fiberglas fabrics coated with synthetic rubbers and resins. These coated fabrics have great tear strength, withstand repeated flexing, and have high dimensional stability—that is, high resistance to stretch or shrinkage Other properties vary with the coating employed, but rubber-coated glass fabrics are being produced which are flame-proof and have high resistance to moisture penetration, decay, and the effects of contact with gasoline, oil, chemicals and greases

High tear strength and dimensional stability, or resistance to heat, chemicals, or oils, are responsible for most of the present uses of the coated glass fabrics. These present uses include aircraft battery covers, oil pressure switch diaphragms, aircraft tape for expansion joints of hot air ducts, protective clothing for workers in chemical plants, and targets for aiming aircraft gun and bomb-bay sights Possible future uses include tarpaulins and other water-proof covers for machinery, water-proof containers for delicate instruments, and carburetor diaphragms. Another possibility is an awning that will not burn if a lighted cigarette is tossed upon it from an upper-story window.

FIBER COMBINATIONS—Glass and asbestos fibers, and glass and asbestos yarns, have been combined to form new glass-asbestos textiles for other specialized applications requiring resistance to high temperatures, together with high strength, light weight, and resistance to the effects of repeated flexing. The high strength of the textile is primarily due to the glass, while the asbestos enables the textile to withstand more flexing than can an all-glass textile.

A start toward combining glass fibers with fibers such as rayon, silk, and cotton was made before Pearl Harbor. Glass fibers were combined



Bobbins of glass yarn, ready for weaving

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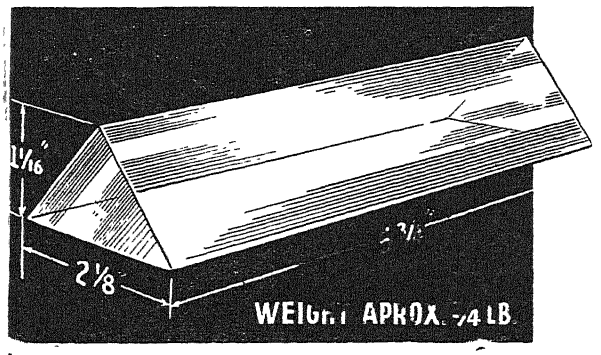
All Items Finely Ground and Polished but Edges Slightly Chipped or Other Slight Imperfections which We Guarantee Will Not Interfere with their Use. All Lenses neatly packed and marked for Diameter and Focal Length.

OUR POLICY on WAR SURPLUS

1. We are cooperating to move surpluses while the war is on.
2. Our customers receive full benefits of all savings effected through our purchases of war supplies. We do not hold merchandise for high future prices.
3. We are making an effort to bring our items to the attention of all Schools, Colleges, Amateurs.



TANK PRISMS

In order that the tank driver shall not get shot in the face, two of these Silvered Prisms are used to make a periscope (without magnification). We have secured a number of these that are very slightly chipped, making possible their sale at a very low price. They are 90-45-45 degree prisms of huge size — 5¾" long, 2⅛" wide, finely ground and polished.

You can use these Prisms to make Periscopes to see over the heads of crowds, fish under water, high or low gauges, inspection of machinery without climbing, for examination of hot metals without danger to eye or camera, etc. Also excellent for experiments, class-room demonstrations at high schools, colleges, camera clubs, astronomy clubs. Some of our ingenious customers have used these Prisms to make camera stereo attachment, photometer cube, range finder, etc. And here's an excellent, unique gift idea. For 5¢ we supply 100 gold letters with which you can turn one of these Silvered Prisms into a desk name plate in 5 minutes of easy work.
Normally, these Prisms would retail from about $24 to $30 each
Stock #3004-S . . . SILVERED TANK PRISM — Price $2 00 each Postpaid. Free Booklet on Prisms incl.
Stock #3005-S . . . PLAIN TANK PRISM — Price $2.00 each Postpaid. This one is excellent for projecting all the colors of the spectrum — a beautiful sight. Free Booklet on Prisms incl.
FOUR TANK PRISMS — Special — $7.00 Postpaid . . . This is the most sensational bargain we have ever been able to offer.

WAR BARGAINS IN LENSES USED IN NAVY'S 7 POWER BINOCULARS

KELLNER EYE-PIECE LENSES with F.L of 27.5 mms Comes uncemented with free cement and easy directions. Edged Field Lens has diameter of 26 mms. and edged Eye Achromat a diameter of 17 mms. Unedged Lenses about 2 mms. larger than edged ones. These are excellent for all sorts of telescopes.
Stock #6060-S — Uncemented and Unedged — 75c Postpaid
Stock #6061-S — Uncemented but Edged — $1 25 Postpaid
ACHROMATIC OBJECTIVE LENSES with F.L of 193 mms. Have wider diameter than those used Army's 7 power binocular. Excellent for telescopes. Diameter of edged lenses are about 52 mms. Unedged about 53 to 56 mms.
Stock #6063-S — Unedged and Uncemented — Price 75¢
Stock #6064-S — Edged and Uncemented — Price $1.75
LOW POWER MICROSCOPE LENS SET — (May also be used to make Telescope Eye-Piece) Perfect Lenses, one with diameter of 9 mms., F.L. of 20 mms., and one with diameter of 14 mms. and F.L. of 39 mms.
Stock #1003-S — Price 70¢ — includes free copy of our Microscope Booklet.

PORRO ABBE PRISMS #3006-S . . . 25¢ each Postpaid
Size 9 mm. by 17 mm. . . . another war bargain. Normal prices would be 10 to 20 times above quotation.

LENS SET 120-S "The Experimenter's Dream" 60 lenses with 70-page illustrated booklet "FUN WITH CHIPPED EDGE LENSES" — $10.00 Postpaid.

The variety of lenses in this set will enable you to conduct countless experiments and build many optical gadgets.

WAR SURPLUS ACHROMATIC LENSES

Stock No	Dia. in Mms	Focal Length	Comments	Price
6016-S	*12	80 mm.	Uncemented	30¢
6017-S	*12	80 mm.	Cemented	50¢
6018-S	*15	41 mm.	Uncemented	40¢
6019-S	*15	41 mm.	Cemented	60¢
6022-S	*25	95 mm.	Uncemented	50¢
6024-S	*25	11 inches	Uncemented	60¢
6025-S	*25	11 inches	Cemented	75¢
6028-S	*30	64 mm.	Uncemented	70¢
6029-S	*35	60 mm.	Uncemented	70¢
6030-S	*36	171 mm.	Uncemented	70¢
6032-S	*36	178 mm.	Uncemented	70¢
6033-S	*37	51 mm.	Uncemented	70¢
6034-S	*38	178 mm	Uncemented	70¢
6037-S	*41	57 mm.	Uncemented	70¢

Free Cement and Directions included with all uncemented sets.

*—Available with magnesium fluoride low reflection coating. Coated lenses will be priced at 10¢ more than the prices shown above. If you want coated lenses, mark "coated" after stock number and include 10¢ extra.

REDUCING LENS SET #1004-S $1.20 Postpaid
Contains a 2½" diameter and 1¾" diameter reducing lens of different powers.

70-PAGE ILLUSTRATED IDEA BOOKLET . . $1.00 Postpaid
Describes wide variety of uses for our lenses and contains much information especially designed for beginners in optics.

SCHOOLS & COLLEGES — Get on our mailing list. Keep regularly posted about our Optical Bargains. Send name, address to our Educational Dept.

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Our Lenses and Prisms make SPLENDID XMAS GIFTS for the scientific-minded person or hobbyist.

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with silk and rayon fibers, for example, to form a necktie fabric. The war halted development of such combinations for non-essential civilian uses but, as war demands permit, further developmental work along this line is certain to be resumed.

Because glass fibers are strong and will not shrink or stretch, they can be employed in conjunction with other fibers to form decorative fabrics—and fabrics used for wearing-apparel accessories such as ties and scarves—which will hold their shape regardless of humidity conditions and the service strains and stresses to which they may be subjected In neckties, the glass fibers help the fabric withstand the effects of repeated creasing.

Production of all-glass decorative fabrics—also halted by the war—will be resumed as rapidly as the war situation permits Already limited quantities of Fiberglas yarns have been released for weaving decorative fabrics to be installed in places of public assembly such as schools, theaters, hotels, and restaurants, where the use of fire-proof fabrics can eliminate a serious fire hazard. Newly developed methods of dyeing and printing glass fabrics now make it possible to provide them in a wide variety of colors, shades, and printed designs.

The danger of mass panic due to fire is not as great in the home as it is in places of public assembly. The feature of fire-safety, therefore, is of lesser importance in the home—except, perhaps, in the case of tablecloths and other table coverings which are always in danger from a carelessly placed cigarette. But Fiberglas decorative fabrics —particularly in the form of draperies —possess other decided advantages for home use

LONG-LIVED DRAPERIES—The above is especially true of seashore homes, where salt air, strong sunlight, and humidity play havoc with some of the older drapery materials. Fiberglas fabrics will not rot or disintegrate under the severest climatic conditions, nor will they stretch or sag under changes in humidity Their colors are fast to sunlight and cleaning Moths cannot eat them.

Need of the Army Air Forces for a high-strength, light-weight, easily fabricated material for load-bearing parts of planes has resulted in the development of a new structural material consisting of a combination of a plastic resin and glass textile fibers. The outstanding characteristic of the material is that it provides hitherto unattainable strength in proportion to its weight, and at the same time permits quick, low-cost fabrication.

The plastic used in the combination may be any one of a number of resins that can be molded under low pressures and cured at low temperatures. The glass fibers are employed as reinforcement, usually in the form of cloths woven of the fibers. Extremely fine fibers, with lengths measurable in millimeters, may also be dispersed in the resin to provide still greater strengths.

Layers of glass cloth are impregnated with the resin and placed, one on top of another, until a laminate of the desired thickness is built up. The laminate is then draped over the mold or shaped in it The mold, with the laminate formed to the desired shape, are placed in an oven where the laminate is cured. Plastic-glass laminates have shown tensile strengths of from 50,000 to 80,000 pounds per square inch, compression strengths of over 50,000 pounds per square inch, and impact strengths of over 30 foot-pounds, as compared with two foot-pounds for ordinary plastics.

A basic objective in aircraft construction is reduction in weight. Weight affects rate of climb, maneuverability, cruising range, fuel consumption, and the amount of live or pay load the plane can carry. All these are important in varying degrees in both military and civilian planes. Every part of the plane, therefore, must be designed for minimum weight while supplying the required strength

POST-WAR POTENTIALS—For every pound of increase in the weight of the plane there is a decrease of a pound in pay load. In passenger and cargo planes, taking the life of the plane into consideration, it has been estimated that every pound of weight saved means a saving of from $100 to $500. Using the lower figure, if only 1 percent of the dead weight of a 45,000-pound gross weight cargo plane can be transferred from empty weight to pay load, the saving during the life of the plane will be $45,000.

"Make it lighter and make it stronger" is an axiom of the airplane designer. Because glass-reinforced plastics provide extremely high strength in proportion to weight, they should be able to contribute materially to the reduction of dead weight, which is the goal of the aviation industry and upon the attainment of which may depend the ability of the plane to compete with other forms of transportation as a large-scale carrier of passengers and freight.

Aircraft provide the most spectacular application of Fiberglas-plastic combinations, but designers and engineers are already experimenting with the material for many other post-war civilian uses. These include strong, light-weight luggage, boats and canoes, furniture, kitchen and bathroom assemblies, refrigerators and radio cabinets, and dozens of additional products where attainment of light-weight combined with high strength and ease of fabrication is the goal.

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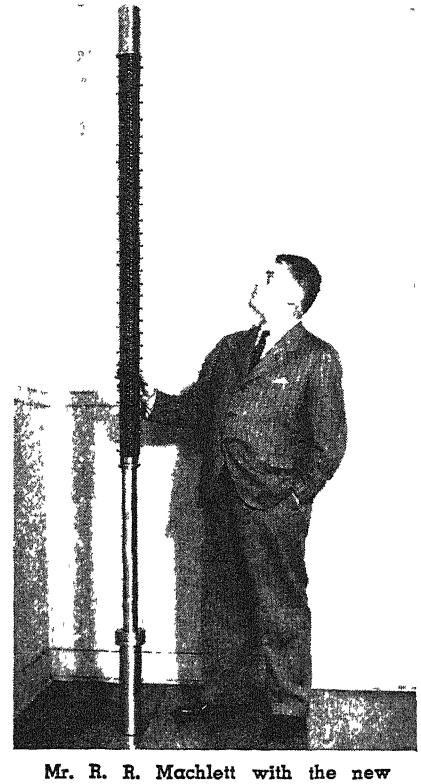
TWO-MILLION-VOLT X-RAY

Precision Tube Greatly Reduces Exposure Time

DEVELOPMENT of a precision x-ray tube that operates at two million volts makes it practical for the first time to inspect by x-rays exceedingly thick sections of metal, reducing the exposure time in a particular instance from a week with a million volts to less than an hour with two million Physicians will likewise welcome the new tube as a more effective tool for research in cancer therapy.

This new precision tube brings to the field of x-ray radiography the same sort of improvement in definition that the electron microscope, compared



Mr. R. R. Machlett with the new precision high-voltage x-ray tube developed in Machlett Laboratories

with the standard microscope, brought to the field of optics.

In many ways the two-million-volt tube made by Machlett Laboratories, Inc, represents a radical departure from the previous art. It is completely sealed off, like an ordinary radio tube, and so the high vacuum within it does not have to be maintained by pumping. It is compact, and can operate at a constant potential with unvarying reliability of results

Development of the tube was undertaken by the Machlett Laboratories for the High Voltage Laboratory of the Massachusetts Institute of Technology. The fundamental requirements were so severe that it became evident that the tube would have to be designed and constructed so as to achieve extremely fine focusing of the high-speed, two-million-volt electron beam This necessitated not only a much improved electron source but, in addition and of greatest importance, a means of accelerating the electrons which, considering the high electron-velocities involved, would provide a constant rate of acceleration over the entire cathode-to-target distance, at the same time reducing to an absolute minimum the dispersion of the beam during its travel.

To accomplish this, the tube was designed to include some 180 sections, in order to provide uniform accelerating

steps of 12,000 volts each. The mechanical problems involved in the design and construction of such a column of alternating glass and metal rings, tight to the vacuum within, able to resist high pressures without, and having adequate insulation, were almost insuperable in the light of the prior art of tube construction.

In order to appreciate the nature of the problem thus presented, it may be pointed out that in the average x-ray tube the total length of glass-to-metal seals is from two to three inches, whereas a column of the kind required in the new tube involves approximately 300 feet of such seals, or over a thousand times the length of the seals in even the larger standard tubes.

Early in the experimental work on the manufacture of this critical column it became evident that the usual gas-flame technique for sealing metal to glass would not do. Eventually the Machlett engineers developed a novel procedure, involving a combination of gas flame and high-frequency induction heating. This is now being successfully used. The metal rings are of Kovar, and have a special configuration to assure complete and homogeneous bonding with the glass.

SYNTHETIC RUBBER FOAM

Compares Favorably With Natural Foamed Latex

THE DEVELOPMENT of a process to produce foam rubber from synthetic latex was announced recently by The Firestone Tire and Rubber Company. This important discovery may mean new safety and comfort for millions of American fighting men. Because foam rubber previously could be made only from scarce natural latex, relatively unsatisfactory substitutes had to be used for tank shock pads, gunner pads, aircraft seat cushions, submarine mattresses, and many other vital war products.

The new synthetic product, as soft and fluffy as an angel food cake, also can be produced in medium and firm densities, and volume production of it already is under way.

Whipped into a creamy froth, much as a housewife beats egg whites for her cake, the synthetic latex traps innumerable interconnected tiny air bubbles, which give the foam rubber its softness and permit free circulation of cooling air.

The finished material compares so favorably with the natural foamed latex which Firestone made before the war that the same name—Foamex—has been given the new product. Foamex is extremely light; it is odorless, washable, and sanitary, and unattractive to moths or vermin.

The tensile strength of the synthetic material is equal to or greater than that made with natural latex, and it can be made to remain flexible at temperatures ranging down to 40 degrees below zero.

The ability of Foamex made from synthetic latex to resist gasoline and oil, which destroy natural rubber products, will give it many important new applications. When soaked in gasoline, the synthetic material increases slightly in volume, but returns to normal when dry. Oil affects it but little.

It is reported that after the war Foamex again will be used for mattresses, automobile and truck seat cushions, furniture upholstery, and similar products

PHOTO-LAYOUT MATERIALS

Offer Many Advantages to Fabricators of Metal Parts

MATERIALS for a simplified method of printing working drawings directly on metal, recently announced by the Eastman Kodak Company, are known as Kodak Layout Paint and Kodak Layout Paint Primer. As the name of the latter implies, it acts as a base for the Layout Paint. The new method is said to be of widespread applicability for the production of flat metal parts

Kodak Layout Paint is sprayed in ordinary room light directly on virtually any primed metal surface with a conventional spray gun, after the surface has been cleaned reasonably free of loose dirt and grease. Drying takes place rapidly and the prepared metal is ready for immediate use or it can be safely stored for a reasonable time in a dark place

The drawing, which has been previously prepared with black ink on a transparent or translucent material, is next laid in contact with the prepared surface and an exposure of a few minutes' duration made to arc or mercury-

A spray of tap water removes all layout paint which has been light-struck, leaving only the lines and figures of the original drawing

vapor lights The drawing is removed and the metal flooded with warm, weak ammonia water. A vigorous spray of tap water follows, which washes away the entire exposed coating, leaving only white lines where black lines appeared in the drawing. Another thin spray coat of Layout Paint Primer protects the finished product

According to Kodak, parts so marked are as accurate as the original drawing. On metal, the new Layout Paint withstands bending, shearing, and punching without showing any tendency to loosen, and will actually resist the application of a cutting torch up to the point where the molten metal carries it away, provided that the metal does not scale.

The new method is said to have a distinct advantage over the scribing method because operators' instructions which are inked on the drawing are transferred to the part to be fabricated. Reductions in scrap loss are forecast because a layout can be prepared so as to include parts for several products. By so doing, maximum use of metal can be achieved. It was further stated that no critical steps are involved and that an inexperienced operator can learn the process rapidly It is anticipated that the new process will be a boon to all fabricators who work with sheets of metal having uneven or oxidized surfaces.

STEEL SAFETY

Maintained Despite War-Time Problems

IN SPITE of difficult conditions, which included a high turnover rate among employees, the steel industry held fast, during 1943, to its high rank in safety, according to statistics of the National Safety Council.

As in 1941 and 1942, the steel industry was third in freedom from accidents among leading industries. Only the communications and electrical equipment industries among 38 major industries stood above steel in safety.

The 1943 accident frequency rate in the steel industry was 7.4 per million man-hours worked, the same as in 1942. The average of all industries was 14.5 last year, compared with 14.9 in 1942

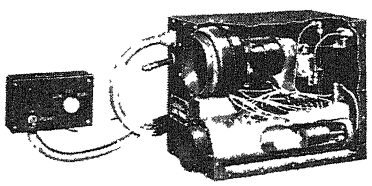
So many persons were hired as replacements in 1943 that a resultant increase in accidents might have been expected in the industry. At the same time, steel plants were operating at high speed to set an all-time record of yearly tonnage output, another obstacle to safety which had to be overcome

The new employees hired to fill the jobs of workers who had entered the armed services were unfamiliar with their surroundings, but safety engineers and departmental officials conducted an unrelenting drive against unsafe practices and saw that every newcomer was adequately instructed

TRUCK HEATER

Pre-Heats Engines for Quicker Winter Starting

NEW truck and bus heaters, announced by the Fluid Heat Division of Anchor Post Fence Company, combine the usual functions of cab heating and windshield defrosting with the addition



All-purpose truck heater that draws fuel from the vehicle's supply tank, with remote control panel at left

of trailer space heating and pre-heating of batteries, engine manifold, and crankcase if desired. Known as Model SAH, these heaters are made in several different sizes with outputs from 10,000 Btu per hour on low rate to 40,000 Btu per hour when firing at maximum rates Controls are remotely mounted

The combustion process of vapor entraining, successfully applied to aircraft heaters, is used The heat exchanger has four compartments with "cross-over" passes between Thus the flame and hot gases have a travel of four times the length of the heat exchanger with the maximum area of heating surface exposed to the heating air. Combustion air is pre-heated in a tube which extends through the length of one exchanger compartment The flame is completely suspended to provide freedom from lead or other formations without regard to the grade of gasoline used, and to insure longer life for burner parts Fuel is drawn from the vehicle's supply tank.

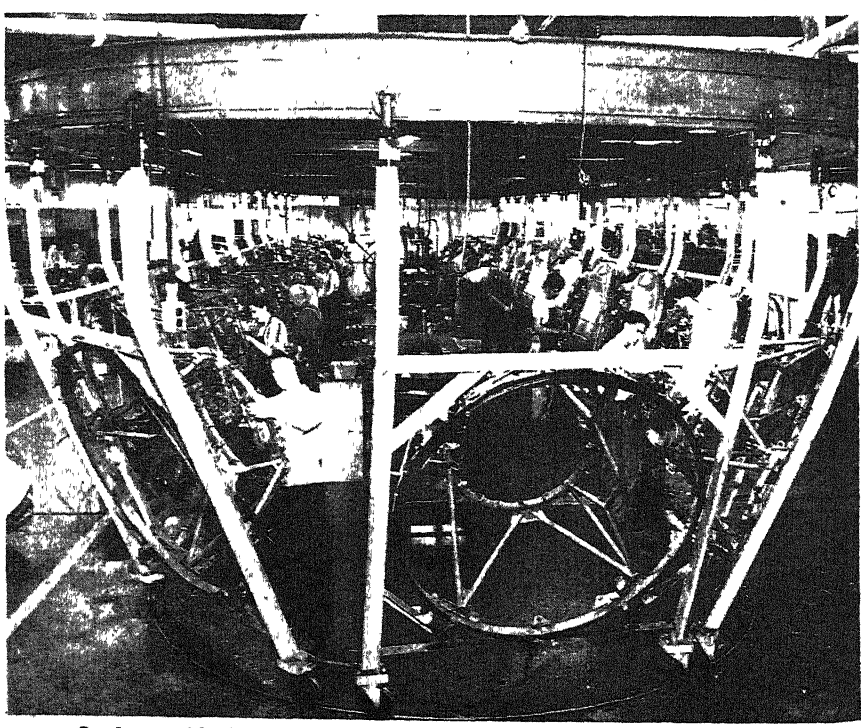
In designing Fluid Heat automotive type heaters, safety was a paramount consideration Therefore the exchanger is constructed of stainless steel with gas-tight, continuous welded seams There are only three moving parts—motor, fan, and a standard automotive type pump

Applications for this heater are found in heavy trucks and trailers, Arctic rescue sleds, mobile laboratories, busses, and other vehicles When mounted on wheels or skids it may be used for pre-heating engines of bulldozers, cranes, compressors, and for numerous other applications where heat is an aid to starting or operating

PLANT MERRY-GO-ROUND

Simplifies Engine Mount Assembly

THE STRAINS of the calliope are missing and there are no horses to ride. but a moving oval jig, used for assembly of fixed cowlings and associated parts on engine mounts for Boeing B-17 Flying Fortresses, in many respects resembles a merry-go-round The assembly line operates on a track suspended from the ceiling and guided by



Oval assembly line, with supporting over-head track and floor guide track

another track on the floor. It holds 24 engine mounts at one time—enough for six Boeing bombers. The mount frame is placed in the jig at one end of the oval When a worker completes one assembly operation, the mount moves to the next operator. After the mount has made a complete circuit, it is finished and ready for removal. Before this moving assembly line was designed and built by Boeing mechanics, it was necessary for an engine mount to be lifted and handled many times during the process of completion

PERFECTED TELEVISION

Claimed by Radio

Industry Executive

APPROXIMATELY $25,000,000 has been invested in television research and development by the radio industry to get television ready for the public, according to James H. Carmine, vice president in charge of merchandising for Philco Corporation.

"Probably never before has the product of a great new industry been so completely planned and so highly developed before it was offered to the public as has television," Mr. Carmine says. "Through long years of research and development, the television art has been so perfected that the product itself and the service it renders will be ready for the public in a highly-developed state as soon as the war is over The best evidence that the public thinks well of television is the universal response that comes from those who have a chance to see it. As soon as television receivers can be made and sold, the public will eagerly buy them in tremendous quantities"

FIBER BANDS

Now Protect Bombs,

Have Other Possibilities

AMONG the recent developments achieved by American industry to meet the "critical materials" situation created by war conditions, is a wheel-like, laminated paper bomb band, a co-operative development of the Alton Box Board Company and the Kenray Company. All bombs, up to 1000 pounds in weight, are equipped with two of these heavy fiber bands which facilitate transportation and handling of bombs and protect the metal lugs on the bomb casing against damage. Every bomb is protected by these bands from the time it leaves the factory until it is placed in the bomb bay of the plane as it prepares to embark on its mission of destruction over enemy targets. The "paper" bands, among other things, permit bombs to be rolled over rough ground with a minimum of effort and danger.

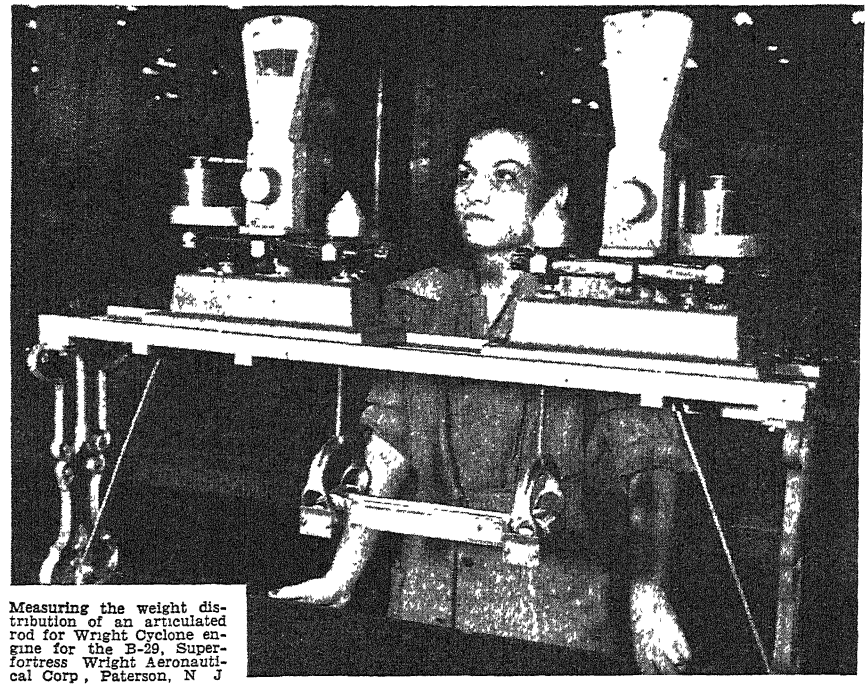
Previous to this development, bombs were equipped with steel bands to serve the same purpose. Each of these steel bands required 13 pounds of critical material—which was reduced to two pounds ten ounces per band through the substitution of paper-board bands. It has been estimated that this change-over has resulted in the saving of approximately 200,000,000 pounds of steel annually.

One of the surprising results of the change-over from steel to paper was that the band was greatly improved from the standpoints of ability to withstand shock and abuse, such as are encountered in combat area operations. In a drag test of 171 feet, a 1000-pound bomb equipped with steel bands showed worse damage than a bomb with fiber bands dragged 1275 feet over the same course. Similarly, in drop tests, steel bands showed failure after two drops, whereas the fiber bands were still in good condition after six drops.

In the development of these "paper" bands, certain rigid conditions had to be met. Specifications called for materials that would be absolutely waterproof—that would withstand rain, mud, and snow, as well as being light in weight and able to withstand extremely severe usage. Employing a synthetic resin base, The Kenray Company developed a moisture-proof adhesive which, when applied to fiber-board, could be immersed in water for a period of seven days and seven nights, at a temperature of 70 degrees, Fahrenheit, without absorbing more than 25 percent moisture.

Equipped with this moisture-resistant adhesive, The Alton Box Board Company went into production on Bomb Bands which are made by machine-winding and gluing paper-board stock convolutely into a solid rim.

This new "material," developed as a war project to meet an urgent need, would seem to have wide industrial



Measuring the weight distribution of an articulated rod for Wright Cyclone engine for the B-29, Superfortress Wright Aeronautical Corp, Paterson, N J

Precision Over Tokyo!

Far to the East are American Machines, many of them . . . keen, effective, destructive. They are the tools of free men who built them . . . who use them in their growing, determined effort to free others oppressed and they will not fail. Pictured here is an articulated rod in the act of being balanced on EXACT WEIGHT SCALES. These rods are vital parts of the famous Superfortress, the B-29 for "Precision over Tokyo" . . . a sinister operation but one no less commonplace than the melting of plow shares into swords during the crusades. This is but a single, and we trust a temporary use for EXACT WEIGHT Scales. One day we will return to handling the commonplace items by the thousands which has been our task for more than twenty-eight years of useful service to world-wide peacetime industry.

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Exact Weight Scales

THE EXACT WEIGHT SCALE COMPANY

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SOUTH BEND LATHES

War production demands uniform accuracy. Loss of time or the waste of scarce strategic materials because of variations in machining cannot be tolerated. There is no place in our war production plan for equipment that cannot be relied upon to maintain required tolerances.

Sound design and careful workmanship give South Bend Lathes the dependable precision that assures uniform accuracy. Built by skilled craftsmen who take pride in their work, they are capable of maintaining split-thousandth tolerances on all work within their capacity. Their unvarying performance speeds production on the most exacting machine operations and assures perfect interchangeability of parts and units.

There is a South Bend Lathe for most war production requirements. The Engine Lathes and Toolroom Lathes are made in 9" to 16" swing, with bed lengths from 3' to 12'. The Turret Lathes are made in 9" and 10" swing. Send for Catalog 100-C.

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SOUTH BEND 22, INDIANA • LATHE BUILDERS FOR 38 YEARS

applications for peace-time production. It is lighter and more shock-resistant than steel, it can be sawed, nailed, or screwed into like wood, is absolutely water-proof and weather-proof, and, finally, can be produced in large volume at relatively low cost.

SYNERGY

Is Acquiring Tremendous Importance in Industrial Chemistry

It is a commonplace of chemistry that a greenish yellow poison gas like chlorine and a bright, silvery, flammable metal like sodium will react to give common table salt or sodium chloride, which is neither sodium metal nor chlorine gas, nor their sum or average. Such behavior is well known in less extreme form to industrial chemists who deal with such things as plastics, fibers, emulsions, ceramics, and protective coatings.

Thus cellulose nitrate is insoluble in alcohol or ether but a mixture of alcohol and ether readily dissolves pyroxylin, yielding a solution known as collodion. Likewise, the effectiveness of pyrethrum, a common active agent of fly sprays, can be increased many fold by the addition of a small amount of sesame oil which in itself is harmless to houseflies These mixtures possess properties not found in the separate ingredients used singly.

All such non-additive effects may be described by the term "synergy." This word has been used for a long time in pharmacology and has Greek roots meaning "working together." The basic idea of synergy may be expressed as "the whole is greater than the sum of the parts" or even as "two plus two makes five." To use the more cautious words of the dictionary, synergy is the "co-operative action of discrete agencies such that the total effect is greater than the sum of the two effects taken separately."

Can anything of value to the chemist be learned from so general a phenomenon as synergy? Do the many different systems displaying synergy possess any common factors in their mechanisms which can guide the industrial chemist in his work?

With these questions in mind, a large number of examples of synergy from diverse fields of industrial chemistry were examined as to type of mechanisms and general factors involved. Three main types of synergic mechanisms were recognized, based on (1) direct interaction, (2) complementary functioning, or (3) combined stepwise action of the components of a system or mixture.

The factors underlying all truly synergic phenomena were found to be self-association, packing effects, dissymmetry, and interaction of components Thus, mixture of an inert diluent with a solvent whose molecules are combined or associated with other molecules of the same substance may cause these associated molecules to separate, thereby altering the solvent properties.

The reaction rate of a chemical may likewise be altered by changes in self-association upon dilution. By employing a mixture of particle sizes in the fillers used in materials such as putty and concrete, higher plasticity at a higher filler content may be obtained as against the use of a single particle size.

This results from the ability of mixed particle sizes to pack more closely. Plastics are made by combining certain compounds or chemical building blocks with themselves many times to form very large chains or networks. By employing a mixture of building blocks, differing in molecular size or polarity, dissymmetry is introduced into the structure of the plastic, thereby altering its solubility, strength, and elastic properties.

Synergy, which is so common in pure or theoretical chemistry as to hardly merit notice, acquires tremendous importance in applied chemistry. It triples the effectiveness of an insecticide or doubles the yield of a reaction. It represents a saving of time and money, conservation of materials, longer life and better use for the creations of the chemist.

Heretofore the application of synergy has been largely the result of long years of accumulated experience, or of some special theory about some particular process, or even the result of chance discovery. There has been a noticeable tendency among chemists to assume that mixtures of similar or related materials would give average properties.

This generalization of the nature of synergy and the factors underlying it which have now been made for the first time in the field of industrial chemistry do not represent any new discovery of principles. They do, however, offer the chemist a valuable new orientation or approach to his problems. Armed with an awareness of the nature of synergy and consciously seeking its utilization, chemists can speed the solution of their problems and better realize the hidden possibilities of the materials they work with. *—From a paper by Pat Macaluso, of Foster D. Snell, Inc., presented before the American Chemical Society.*

New Products

TOUGH FLOORS

ALL floors in industrial plants, especially loading platforms, receiving and shipping room floors, corridors and runways are subject to heavy traffic, shock, and abrasion Consequently, floor troubles are frequent. Maintenance men have been demanding tough, durable floors which are not slippery, show no noticeable wear for long periods and involve practically no upkeep costs. It is claimed that such floors can now be constructed with Ferem, a concrete component developed by the laboratories of the A. C. Horn Company.

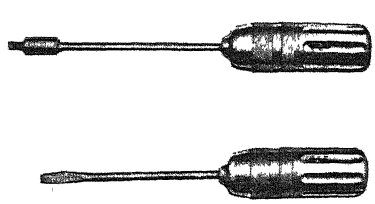
Ferem is a complete material containing all the desirable characteristics of concrete hardeners, admixtures, and processed components. Ferem contains no sand, stone, or silica and requires only the addition of cement and water. Ferem "Blue Temper" floors are reported to be unusually resistant to wear, water, and chemical disintegration. The principal component of Ferem has a rating of 9 in hardness on the Mohs scale, which is only one point less than the diamond.

Ferem is used exclusively as the "Blue Temper" component in place of sand and gravel or stone in floor toppings in dairy or creamery floors and in industrial plants where the floors are subject to heavy traffic or where resistance to water, oil, and dilute acid spillage is required.

TORQUE SCREW DRIVER

SAID to completely eliminate all danger of over- or under-tightening, thread stripping, or material-damaging, a new torque screw and bolt driver has been announced by Richmont, Inc. It is 7¾ inches long, with a 1.30 inch diameter handle.

This new driver, known as the Livermont Roto-Torq, may be adjusted to



Available in two models, this torque screw driver is easily adjustable

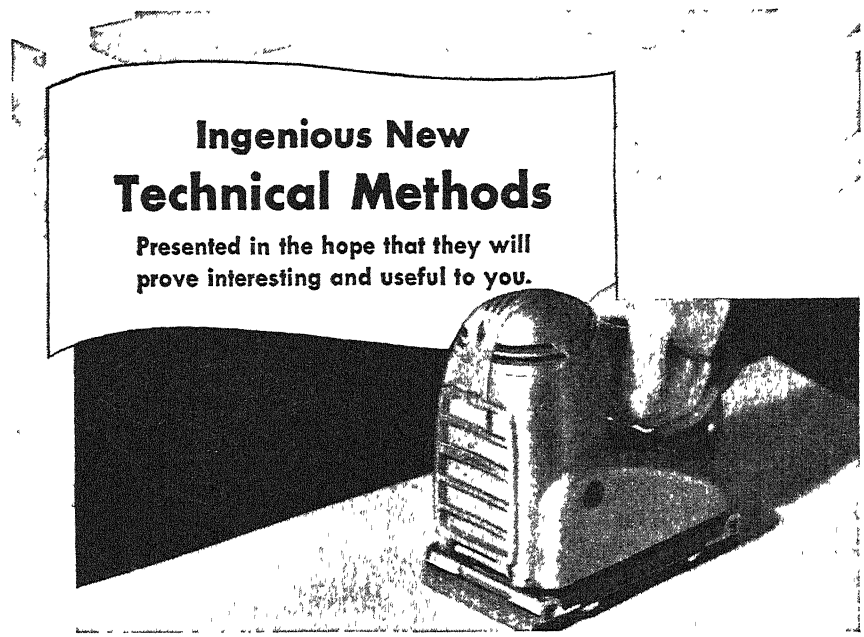
any torque desired between 1 inch-pound and 25 inch-pounds for setting screws, small nuts, bolts, and so on. Because it disengages itself at the proper torque, it is impossible for the operator to tighten beyond the prescribed fit or tightness.

The mechanism operates on a spring principle and is not to be confused, it is said, with a clutch, cam, or friction principle. Torque tolerances are very close and the torque is not influenced by excessive oil or other normal foreign material, nor by the way it is held or used by the operator.

ROTARY PUMP

A NEW low-pressure rotary pump, which is designed for industrial application and affords an efficient and economical method for pumping all types of liquids having lubricating qualities, has been announced by the John S. Barnes Corporation. The new Barnes pump is ideally adapted for use as a lubricating booster pump for oil lines, a gasoline dispensing pump, and for oil pressure systems on automotive, truck, or tractor equipment. It has also proved ideally suited for use on Torque Converters. Capacity of the Barnes pump ranges proportionately from one gallon per minute at 600 revolutions per minute to four gallons per minute at 2400 revolutions per minute. It has a high volumetric efficiency when pumping extremely low viscosity fluids.

An outstanding feature of the new pump is the Barnes patented spur gear tooth form. Tooth construction of the



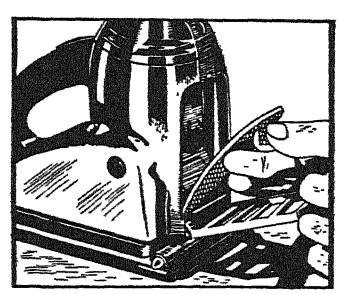
No Vibration in New "Orbital Action" Portable Electric Sander; Relieves Workers' Fatigue

A boon to workers' nerves and health, this new "Orbital Motion" electric sander is actually vibrationless. A great saver of workers' energy as well as man-production hours, the sander can be operated easily in horizontal, vertical or inverted position with one hand. Compared to manual sanding, this machine achieves superior results at least eight times faster. It performs equally well on wood, metal or plastics.

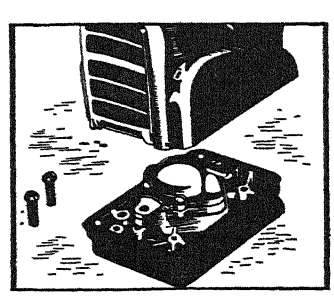
Developed for war industry, this revolutionary new sander has done yeoman duty in this country's manufacturing plants and in allied maintenance and repair depots all over the world.

Wrigley's Spearmint Gum renders a real service to workers too—eases dry throat and relieves tension that brings on fatigue, leaving both hands free to stay on the job. The Army and Navy were quick to appreciate these benefits, that's why they are now shipping to our fighting forces overseas only, our entire limited production of Wrigley's Spearmint. Just as soon as we can supply the home front, too, industry will again enjoy the benefits of Wrigley's Spearmint Gum now proving so important on the battle fronts.

You can get complete information from Sterling Tool Products Company, 155 East Ohio Street, Chicago 11, Illinois



Easily-removed filter cleans air that cools motor—prolongs motor life and reduces maintenance costs.



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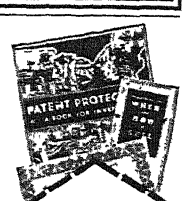

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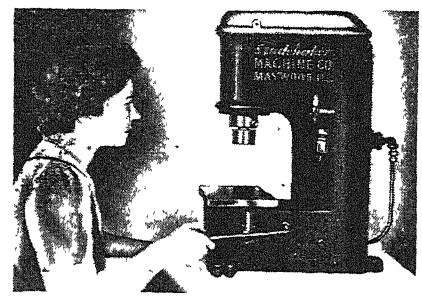
HYDRAULIC SPEEDPRESS

AN ENTIRELY new air-hydraulic gap type speedpress, announced by Studebaker Machine Company, can exert a maximum pressure of 1¾ ton

Inexperienced operators encounter no difficulty in working with this press.



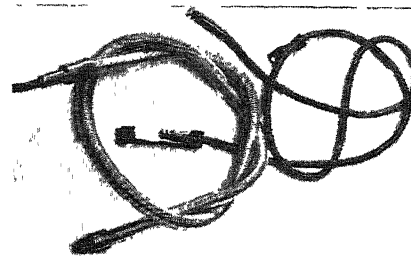
Maximum pressure 1¾ tons

The operator simply pushes down this hand (or foot) control and the ram quickly travels the set stroke from 1/32 to 2½ inches, and delivers pre-selected pressure Operator releases control, and ram retracts automatically.

Air cylinder and hydraulic pump units are built into this press body and are easily accessible and removable. It is the fastest of all presses where speed is needed—or the ram can be slowed down to meet exact requirements

FLEXIBLE HEATING UNITS

FLEXIBLE "serpentine" electric heat units have recently been perfected by the H. and A. Manufacturing Company, Inc. These new units can be coiled in close or in widely spaced turns around



Heat for any shape

pipes and cylinders, spiraled around molds, or fitted to odd contours.

Of metal-ceramic construction, the units can be made in varying lengths and diameters and in capacities up to 15 to 20 watts per lineal inch. Exact temperatures up to 1000 degrees, Fahrenheit, can be maintained without deterioration of the steel-ceramic structure.

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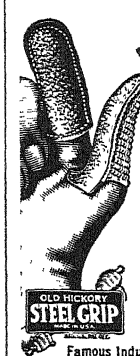

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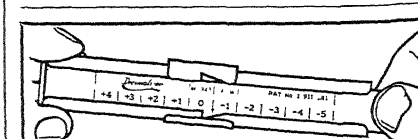

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posed or may be sealed or coated over with insulating cement

Applications already have been designed for de-icing installations on airplane engine nacelles and on hangar doors; also on molds where critical temperatures must be maintained, and on melting pots of unusual shapes. Other applications include the heating of pipes and valves carrying viscous fluids. Experimental work is being done on various applications in the plastic field.

HYDRAULIC GUN

A PORTABLE 1½ ton capacity hydraulic press with off-set platen and ram, identified as Hy-Mac hydro-squeeze gun and built for pressures up to 1000 pounds per square inch, is announced by Hydraulic Machinery, Inc. Two ball-type switches are conveniently lo-

Working stroke is 1½ inches

cated on the unit to control a spring-returned four-way valve As long as both switch buttons are pressed, the valve solenoid is energized and oil under pressure is valved into the gun, moving the ram through the working stroke of 1½ inch When one or both buttons are released, the valve solenoid is de-energized and the ram starts the return stroke.

The off-set platen and ram are constructed to accommodate special adaptors for various operations, such as pressing bushings and pins, riveting, dimpling, and so on.

This gun will reach many hard-to-get-at places, formerly inaccessible to power tools A standard Hy-Mac hydraulic power unit, complete with pump, motor, tank, and valves, generates the hydraulic power for operation of the gun.

PLASTIC CEMENT

PLIASTIC Cement is the name of a synthetic resin adhesive recently announced by Paisley Products, Inc It is a white fluid cement that may be used in its natural state or reduced with water. Application is by brush, gumming machine, spreader, dipping, flow, or spray gun. The manufacturer states that Pliastic is compounded of selected resin bases with complex non-resin mate-

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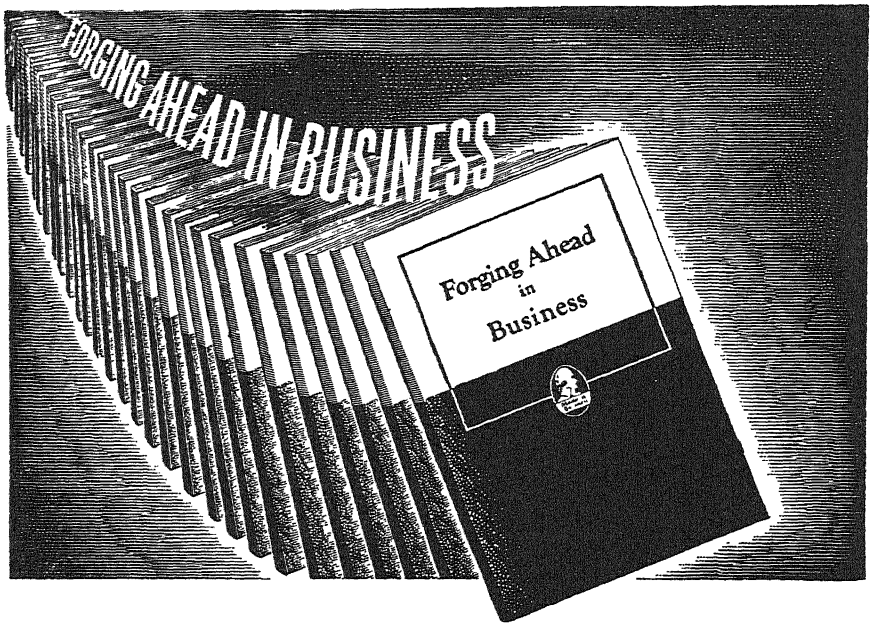

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rials to yield a tough, pliable, continuous film capable of joining many combinations of materials.

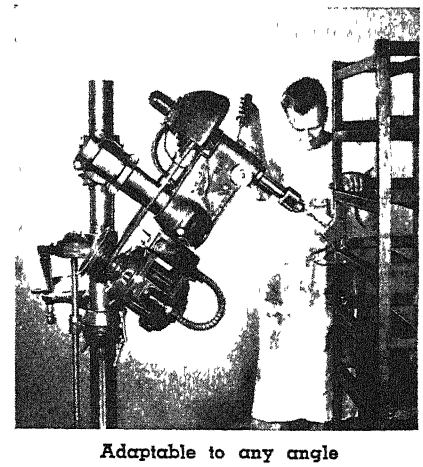
The Pliastic film, when dry, is a semi-transparent, glossy, flexible coating with excellent heat-sealing properties. When used in the liquid state for bonding materials it can be applied to one or both surfaces, the speed of setting being dependent upon the porosity of the materials used.

According to the manufacturers, Pliastic is being used in many industrial operations as a replacement for rubber latex on the following materials: paper, cardboard; wood; plywood; Presdwood; asbestos, cotton, wool, and hair felt; abrasive grains; tinsel and glass beads, plain or treated fabrics; cork; rock-wool and Fiberglas insulation; leather, plastics; porcelain; metals; stone; and many painted, lacquered, and coated surfaces.

DRILL-PRESS BRACKET

JUST announced by the Nobur Manufacturing Company is a new angle bracket that will convert any drill press into one of the handiest, most versatile machines in a shop

This angle bracket changes a drill press into an all-purpose machine for angle drilling, polishing, buffing, sanding, rotary filing, wire brushing, tapping, reaming, burring, grinding, honing, and for many more specialized and varied uses.



Adaptable to any angle

According to the manufacturer, this angle bracket is a quick and inexpensive answer to the hundreds of tedious jobs that demand speed and efficiency Spindle angles can be adjusted to any height, placed horizontally or vertically, at any angle, and can be set for greater convenience and operator comfort. It fits the machine to the work—and gets more work out of the machine.

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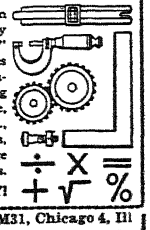

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possesses, or is able to retain and use with facility after leaving school.

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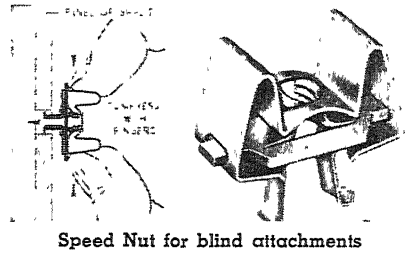
CAGE TYPE SPEED NUT

NO RIVETING, welding, or spinning operations, nor any special tools, are necessary to install a new self-locking Speed Nut in screw-receiving position for blind attachments It is necessary only to compress the cage as shown in the

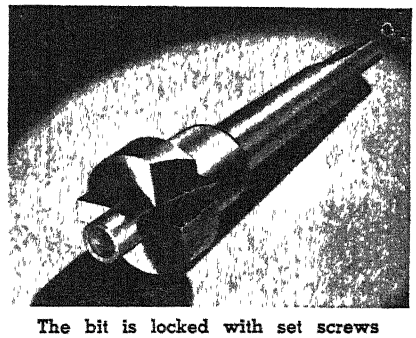


Speed Nut for blind attachments

sketch and to insert the legs The legs spring apart when pressure is released, the turned-up ends just clearing the back of the panel. The nut will hold tight against the force of inserting the screw and the screw-tightening torque, and the floating Speed Nut within the cage allows for any misalinement of clearance holes.

FACING TOOL

THE Multifacer, applicable to drill presses, engine and turret lathes, and milling machines for spot facing, boring, counterboring, valve seating, and cut-



The bit is locked with set screws

ting convex or concave annular rings, is a new tool introduced by The Rieger Manufacturing Company.

The head of the Multifacer is slotted for the insertion of a bit ground to the desired contour. The bit is locked in place with three set screws and can be

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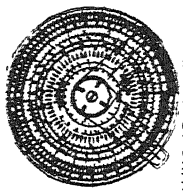

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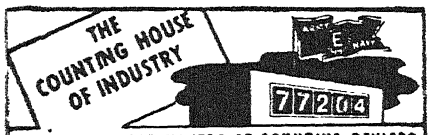

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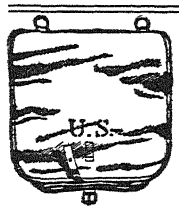

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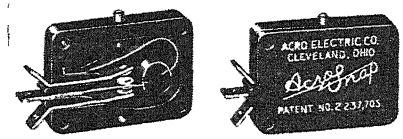

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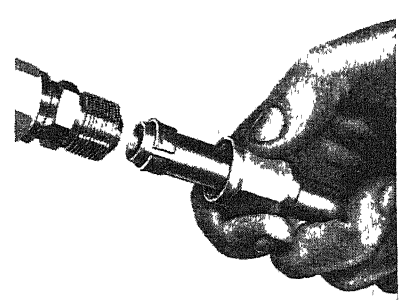

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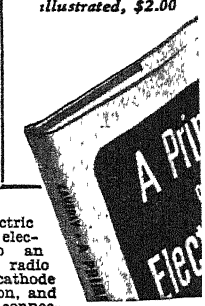

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Telescoptics

A Monthly Department for the Amateur Telescope Maker

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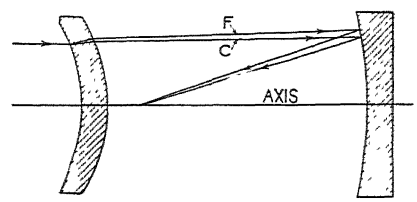
Two months ago, in this department in the October number, Norbert J Schell, 1019 Third Avenue, Beaver Falls, Pa, presented the fundamentals of the new type of telescope invented by D D Maksutov of the State Optical Institute, Moscow In the following article, he concludes that discussion for the immediate present In the meantime 13 advanced amateurs, whom we have dubbed "The Mak Club," though there really is no formal organization other than a common interest and consciousness of a common, parallel aim, have ordered 8 2" disks (slightly larger and more finished—molded roughly to curve—than was mentioned two months ago) of optical glass of suitable specifications from Corning Glass Works, with which to make the thick meniscus lens which, with a spherical primary mirror, is the basic part of the Maksutov telescope "The Mak Club" is open to all martyrs to science who wish to be pioneers, and more glass is said to be available, the disks alone at $32 50 or with a grinding tool of similar deep-curved shape and non-optical glass, at $40 Schell's discussion follows

In the first article on the new Maksutov type of telescope, in the October number, which was necessarily of a general nature, it was possible to mention only certain of this telescope's features. Since Maksutov has offered his design as a solution of the problem of producing a telescope having a wide field of good definition, free from chromatic aberration and at the same time possessing the important advantages of simplicity and ease of construction—features not found in any previous type—it is felt that a further and more detailed analysis of its operating principles should be made in this second article. It is hoped that, by this means, and as a supplement to the first article, the working principles will be covered, and that the two articles will serve as a foundation for later discussions.

CORRECTING ACTION—As stated in the first article, in the Maksutov telescope the negative spherical aberration of the spherical mirror is compensated by the positive spherical aberration of the meniscus lens This is accomplished as a part of the overall diverging action of the lens. In the example given, of an 8" aperture, *f*/4 system, the radius of the mirror was stated to be 65.856" If this mirror were reflecting incident parallel light, the rays from a very small area at its center would come to a focus at a distance of half its radius, or 32.928", while the rays from a zone of 8" diameter would have a focus of 122" shorter, or 32 806" (This is in accordance with our familiar formula of $r^2/2R$, where r is radius of zone and R radius of mirror) In the Maksutov, however, the distance S from mirror to focal plane comes out as 33 6" From this it can be seen that the meniscus acts as a negative lens, diverging the rays and lengthening the distance from mirror to focal plane for all zones including the center. The action gradually increases from the center toward the periphery, so that the rays from all zones are brought to (practically) the same focal plane. In this case, within tolerances mentioned below, we can consider the minimum



amount of lengthening to be 672" at center, and the maximum .794", at outer zone, indicating the effect of the longest and shortest negative focal lengths, respectively, of the lens, in other words, its spherical aberration. (I am indebted to J. H King for the information that designers usually refer to a weak lens of this kind as a lens of "zero power"—a point well taken and worth remembering)

RESIDUAL ABERRATIONS—In the Maksutov system, with spherical surfaces on both the meniscus lens and mirror, an overall correction is attained in the above manner, but it is not possible to secure an exact theoretical correction for all zones, nor for all wavelengths of light, and thus residual aberrations, both spherical and chromatic, remain The extent of these residual aberrations determines the upper limits of aperture-focal ratios and aperture dimensions possible without deterioration of image quality.

In determining the effect of theoretical (or actual) aberrations on image quality, we must take into consideration the maximum resolving power of any given aperture as associated with the wavelength of light. Briefly, it has been shown by mathematical methods that, in a theoretically "perfect" optical system, the image of a point source does not conform strictly to geometric proportions, but consists of an interference pattern having a central concentration, or disk, of finite size, surrounded by so-called diffraction rings, with most of the light in the disk, and that the diameter of the disk is inversely proportional to aperture diameter with a given wavelength of light This disk is also known as the "Airy" disk It has also been shown that if any aberrations in an optical system do not result in optical path differences between source and image greater than plus or minus ¼ wavelength of light, they will cause neither a noticeable change in the size of this disk nor in its relative intensity. In aiming for unimpaired image quality, aberrations within the above limits may therefore be considered as allowable tolerances.

SPHERICAL ABERRATION—The control of residual aberrations consists of such adjustment of the design factors as to bring about a balanced correction with respect to a plane of "best focus," which may be referred to as the "focal plane," having as nearly as possible a minimum variation for different wavelengths of light and a minimum tendency to produce coma. It is obvious that, where there are differences, the "focal plane" will fall somewhere between the shortest and longest focal lengths The differences may be termed displacements, either plus or minus, relative to the "focal plane." While spherical aberration concerns theoretical focal lengths of different wavelengths for the various zones of the aperture, a satisfactory balance can be found by adjustment for a single intermediate wavelength; provided chromatic dispersion is also balanced as will be described. By calculating the theoretical longitudinal displacements of focus for different zones in terms of angular dimensions, the "focal plane" is established as the plane in which equality of angular aberration is found for the extremes of such aberrations both plus and minus. The aim of the adjustment is to reduce the angular aberration at the "focal plane" to a minimum.

In the design data given in the October article for the *f*/4 system, the minus extreme (corresponding to shortest focal length) is identified with the 85 percent zone of aperture, and two identical plus extremes with the 35 percent and 100 percent zones. The "focal plane" lies between the focus for the 85 percent zone and that for the 100 percent zone. (The focal lengths of the 35 percent and 100 percent zones are not identical, as angular aberration decreases with aperture.) This adjustment is the best possible for spherical surfaces, as given by Maksutov, and is perfectly logical, but a fuller treatment will have to be postponed until such time as a mathematical discussion can be prepared.

CHROMATIC ABERRATION—As the meniscus lens is a single lens, it is natural that the question of its chromatic dispersion should arise, even though it is understood that this lens has a very long focus and therefore causes little dispersion. It is obvious that considerable variation in chromatic aberration could be expected, in a system of this kind, among lenses having dif-

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ferent design characteristics. Maksutov found that, if the lens was made of sufficient thickness and suitable radii, chromatic aberration could be eliminated at the focus of a certain chosen zone of the aperture and held to a negligible amount for other zones.

The action for this zone is shown in schematic form in the drawing The usual spectral lines *C* (in the red) and *F* (in the blue) are shown, since the brightest part of the visual spectrum falls between these lines. The *F* line is refracted more than the *C* line and consequently diverges more after passing through the lens, so that it reaches the mirror at a point where it is reflected at a greater angle than the *C* line and thus meets the *C* line on the axis For zones outside of the zone indicated, the *C* and *F* lines cross before they arrive at the axis, and for the inner zones they do not meet before crossing the axis In the design data given, this zone is near the zone of extreme minus spherical aberration for mid-wavelength, previously mentioned Stated differently, the dispersion, relative to this zone, is over-corrected for outer zones and under-corrected for inner zones.

This (corrected) zone is chosen so that the dispersion on either side of it, at maximum, is approximately the same with respect to theoretical angular dimensions at the focal plane. Actually, the dispersion (within the above limits) represents the difference between the residual spherical aberrations for the *C* and *F* lines and, when distributed as indicated, consists of only a fraction of the total aberration.

DESIGN LIMITS—If the aberrations are controlled and minimized in the above manner, the allowable tolerances first mentioned fix the upper limits for design with maximum resolving power These limits are those given in the table with the first article, and it is felt pardonable to repeat that they apply to spherical surfaces only. It is well, however, to consider that these limits are theoretical and, as such, can be expected to be attained with unimpaired image quality only if the glass specifications as well as radii and thickness dimensions are exactly realized It is obvious that a departure in any of these factors will have the effect of widening the aberrations to some extent. On the other hand, as may be inferred from the table, the aberrations quite rapidly become smaller than the tolerances for resolving power as the aperture-focal ratio is reduced below the indicated upper limit for a given aperture By taking a somewhat smaller aperture-focal ratio than the upper limit, in an actual design, we secure the advantage of a certain amount of tolerance for glass characteristics as well as for radii and thickness, which is highly desirable from a practical standpoint.

It is hoped that the amount of freedom in this respect can be determined and made available as a guide within a reasonable time. The very attractive prospect of producing a telescope capable of superlative performance, requiring nothing more difficult than spherical surfaces of a reasonably accurate radius, would seem to dictate the logical choice of design.

COMA AND FIELD CURVATURE—It is not feasible to outline coma without a more or less complete mathematical treatment, which present space does not permit; however, it can be understood in the Maksutov by comparison with the action in the Schmidt camera It will be recalled that the correcting plate in the Schmidt is located at the center of curvature of the mirror, and for that reason light from any part of the field is reflected symmetrically, consequently coma is not produced In the Maksutov, while the lens is not located as far from the mirror, the action is similar, and coma is reduced to a negligible quantity over a wide field In the data previously given, for the *f*/4 system, a field diameter of upward of two degrees is indicated without noticeable coma.

This brings up the question of field curvature, which was not previously mentioned. In this respect the Maksutov is again similar to the Schmidt camera; while its field is curved, the curvature is convex toward the mirror This is the opposite to that in ordinary telescopes and should be of advantage in visual instruments, especially for short focal lengths, as the field curvature, concave toward the eyepiece, will be in the same direction as that of usual eyepieces, providing a closer "match" between their fields

APPLICATION—Pending further descriptions of more complex designs available with this system, a final word is added regarding the possible applications of the fundamental system so far mentioned As it is a corrected system, it can be considered and used the same as a corrected mirror, in any of the following applications.

1: For direct photography, with convex sprung films.

2. As a Newtonian, with diagonal, and so on, in any of its forms, and should be an exceptionally good "Richest Field" instrument; of course, with suitable eyepieces for this purpose.

3: As a primary for a Cassegrain—in which case the secondary would have to be corrected to hyperbolic form in the regular manner.

4: As a primary for a Gregorian—also with corrected secondary of usual elliptical form

5· Off-axis forms Since what is true of the whole is true of a part, a section of diameter representing somewhat less than half of the full aperture in the fundamental design, wholly on one side of the axis, will function without any obstruction in the light path This achievement, with spherical surfaces, requires special constructional considerations, also reserved for future articles.

In both the Cass and Greg, as mentioned above, the secondary focal planes would not be free of coma over as wide a field as at the primary focus, but this should not be noticeable in the smaller fields usually available in such instruments.

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